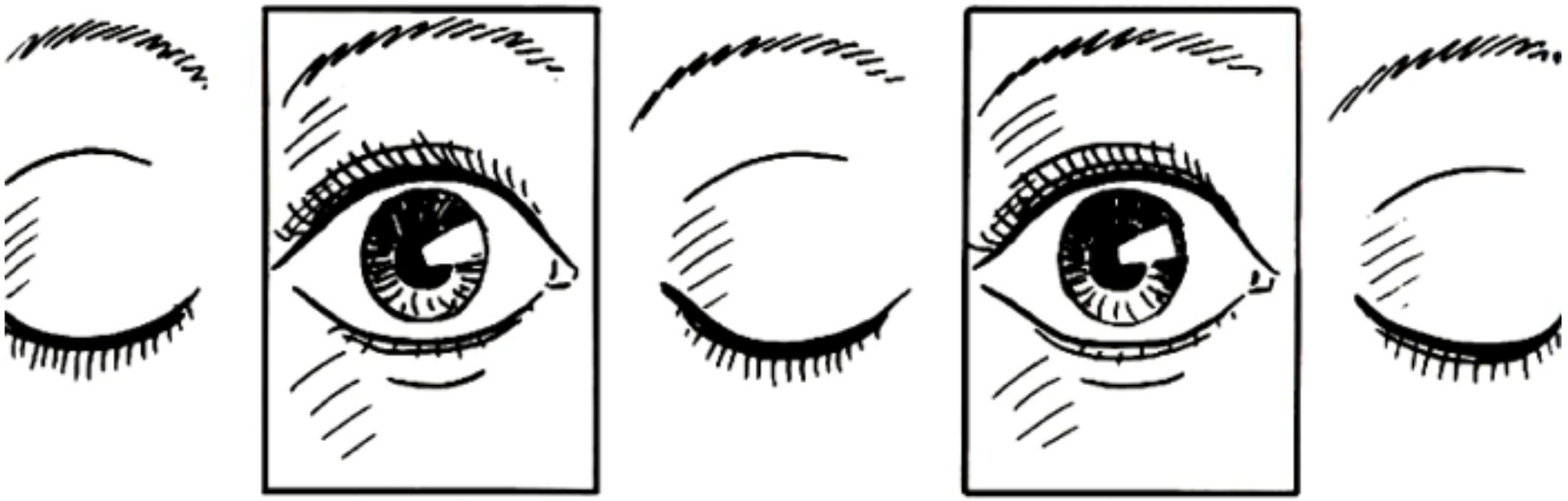
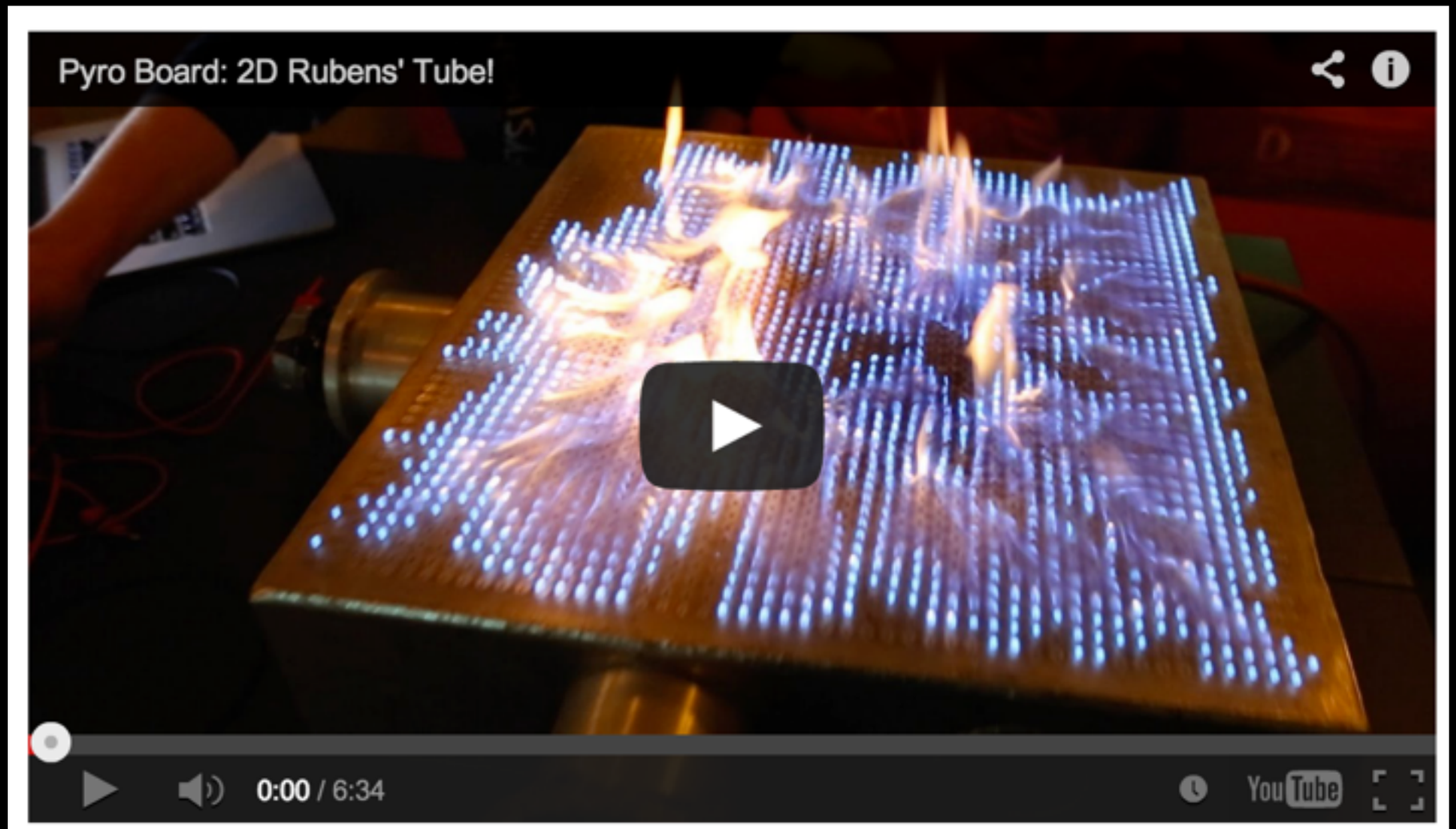
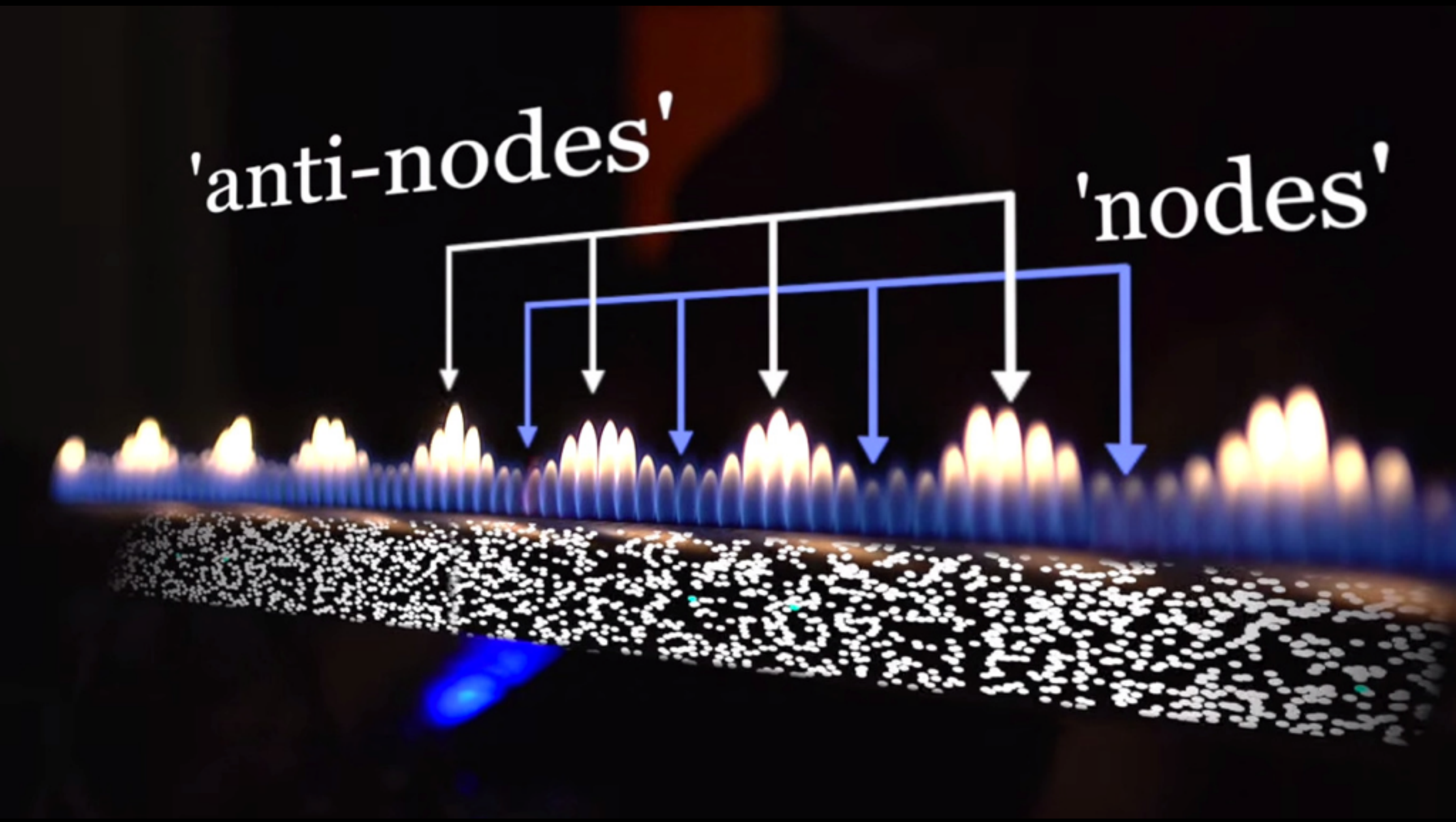


CS247L

May 21. Wednesday.
Data Visualization Techniques



https://www.youtube.com/watch?v=2awbKQ2DLRE


'anti-nodes'
'nodes'

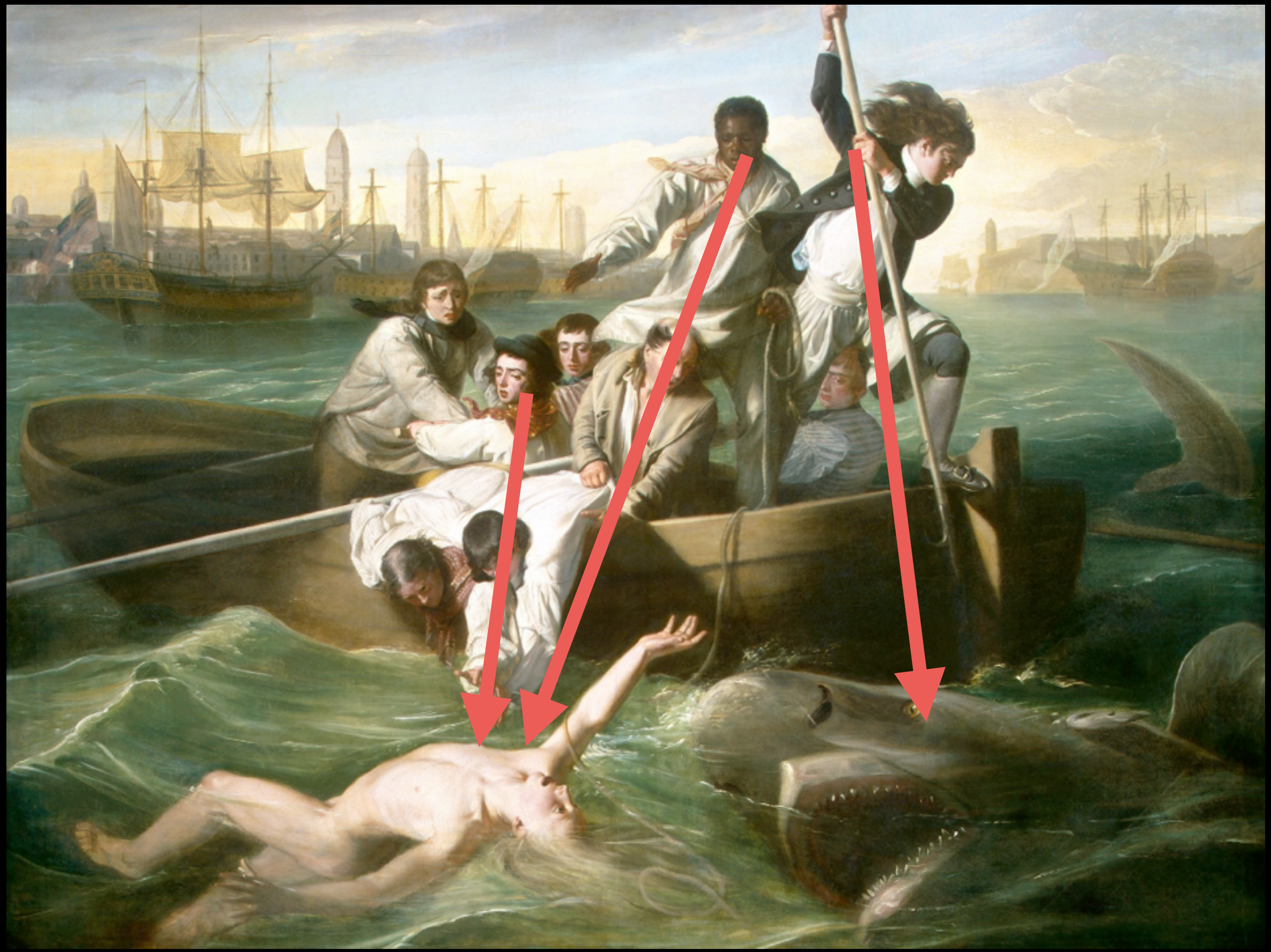
- Some Theory
- Basic Visual Type
- Perception
- Animation
- Interactivity
- Implementation

Why

- Answer questions (or discover them)
- Make decisions
- See data in context
- Expand memory
- Record information
- Blueprints, photographs, seismographs, ...
- Support graphical calculation
- Find patterns
- Present argument or tell a story Inspire

Story telling (to human) **with Data** (from computation)

Movies, music, literature, all tell stories…



PRICE $4.99

THE NEW YORKER

MAR. 20, 2006

SETH

PRICE $3.50

THE NEW YORKER

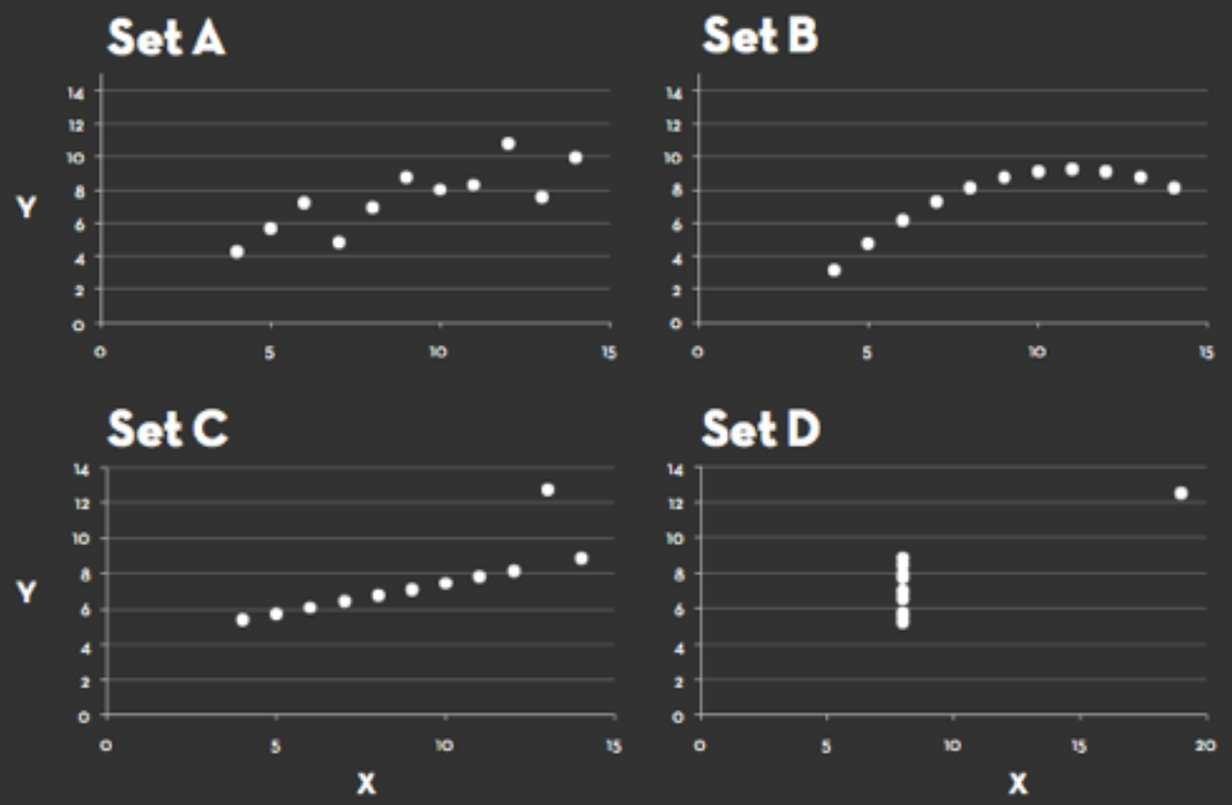
JULY 30, 2001

Set A		Set B		Set C		Set D	
X	Y	X	Y	X	Y	X	Y
10	8.04	10	9.14	10	7.46	8	6.58
8	6.95	8	8.14	8	6.77	8	5.76
13	7.58	13	8.74	13	12.74	8	7.71
9	8.81	9	8.77	9	7.11	8	8.84
11	8.33	11	9.26	11	7.81	8	8.47
14	9.96	14	8.1	14	8.84	8	7.04
6	7.24	6	6.13	6	6.08	8	5.25
4	4.26	4	3.1	4	5.39	19	12.5
12	10.84	12	9.11	12	8.15	8	5.56
7	4.82	7	7.26	7	6.42	8	7.91
5	5.68	5	4.74	5	5.73	8	6.89

Summary Statistics
$u_X = 9.0$ $\sigma_X = 3.317$
$u_Y = 7.5$ $\sigma_Y = 2.03$

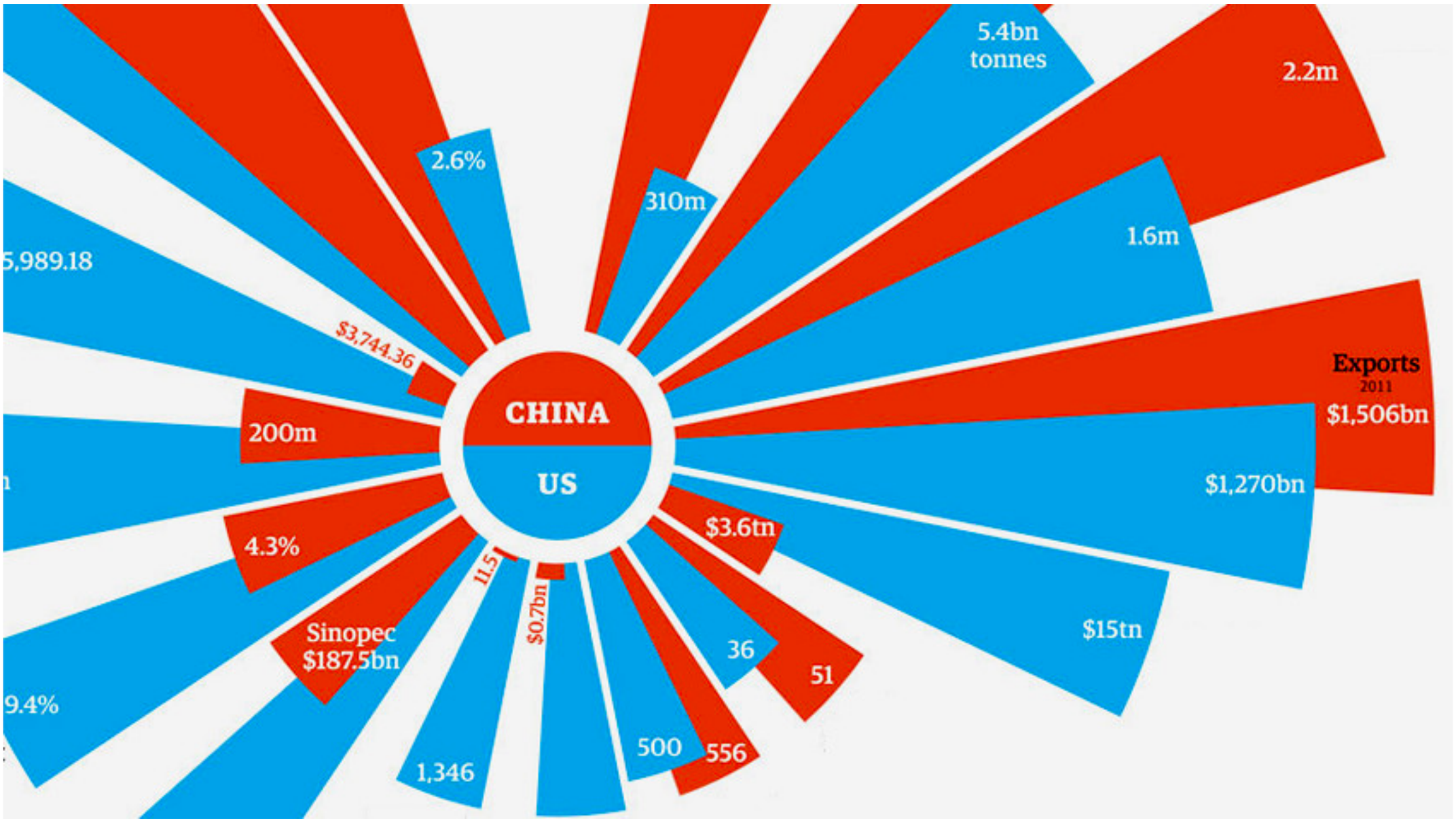
Linear Regression
$Y = 3 + 0.5\,X$
$R^2 = 0.67$

[Anscombe 73]

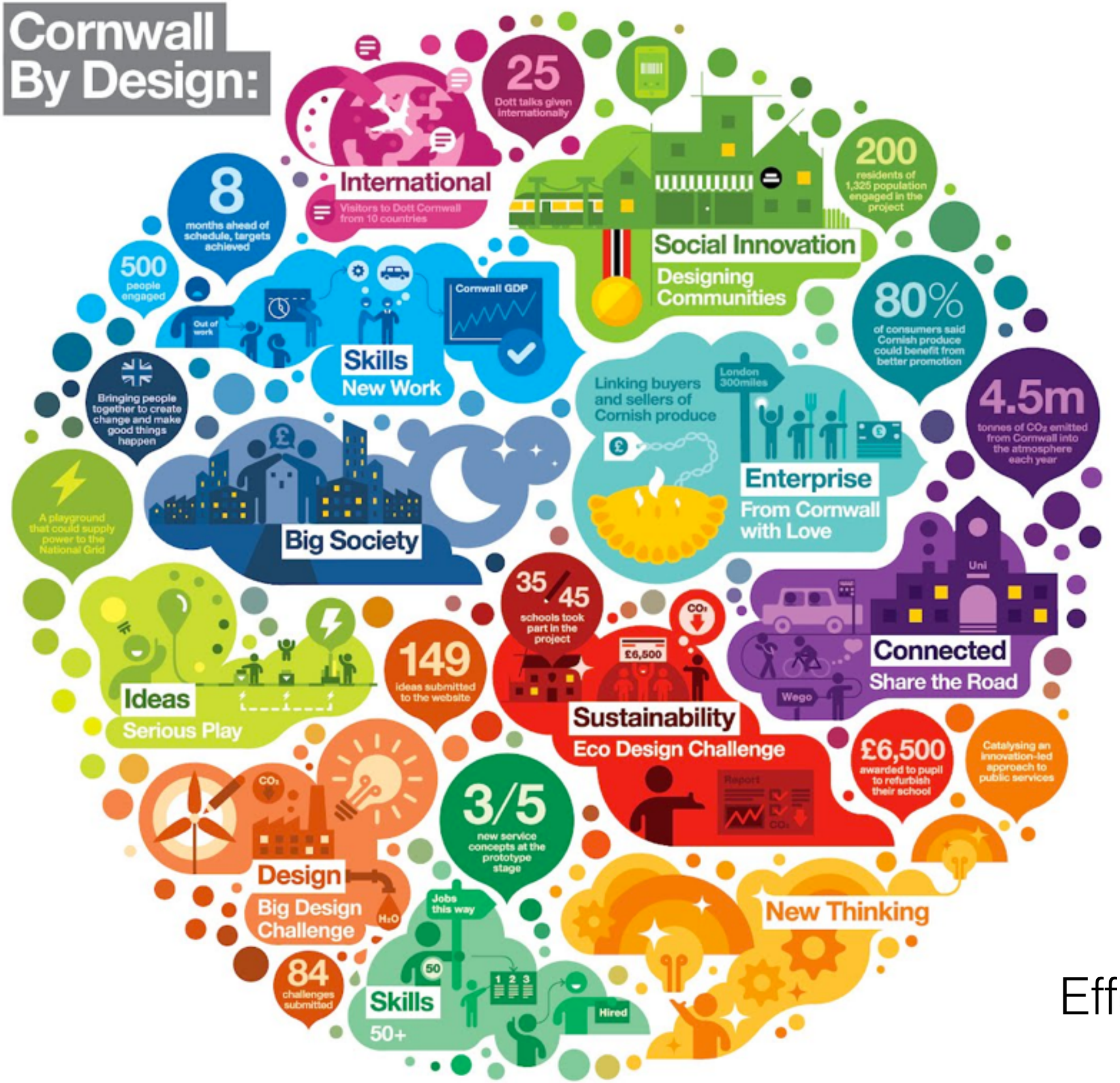


The technique …VS… subject matter.

Data Vis to relate to **subject matter**, allow generating new **insights**, and communicate an **intent** or a **story**.


5.4bn
tonnes
2.2m
2.6%
310m
1.6m
5,989.18
$3,744.36
Exports
2011
$1,506bn
CHINA
200m
US
$1,270bn
4.3%
$3.6tn
11.5
$0.7bn
Sinopec
$187.5bn
$15tn
36
51
9.4%
500
556
1,346

Bad example?


Cornwall By Design:
25
Dott talks given internationally
International
Visitors to Dott Cornwall from 10 countries
8
months ahead of schedule, targets achieved
500
people engaged
Out of work
Cornwall GDP
Skills
New Work
200
residents of 1,325 population engaged in the project
Social Innovation
Designing Communities
80%
of consumers said Cornish produce could benefit from better promotion
Bringing people together to create change and make good things happen
Linking buyers and sellers of Cornish produce
London 300miles
Enterprise
From Cornwall with Love
4.5m
tonnes of CO2 emitted from Cornwall into the atmosphere each year
A playground that could supply power to the National Grid
Big Society
Uni
35/45
schools took part in the project
£6,500
Connected
Share the Road
Wego
149
ideas submitted to the website
Ideas
Serious Play
Sustainability
Eco Design Challenge
Report
£6,500
awarded to pupil to refurbish their school
Catalysing an innovation-led approach to public services
3/5
new service concepts at the prototype stage
Design
Big Design Challenge
H2O
Jobs this way
50
1 2 3
Hired
New Thinking
84
challenges submitted
Skills
50+

Effective?

WATCH THIS SPACE. INFOGRAPHICS ARE 'IN'

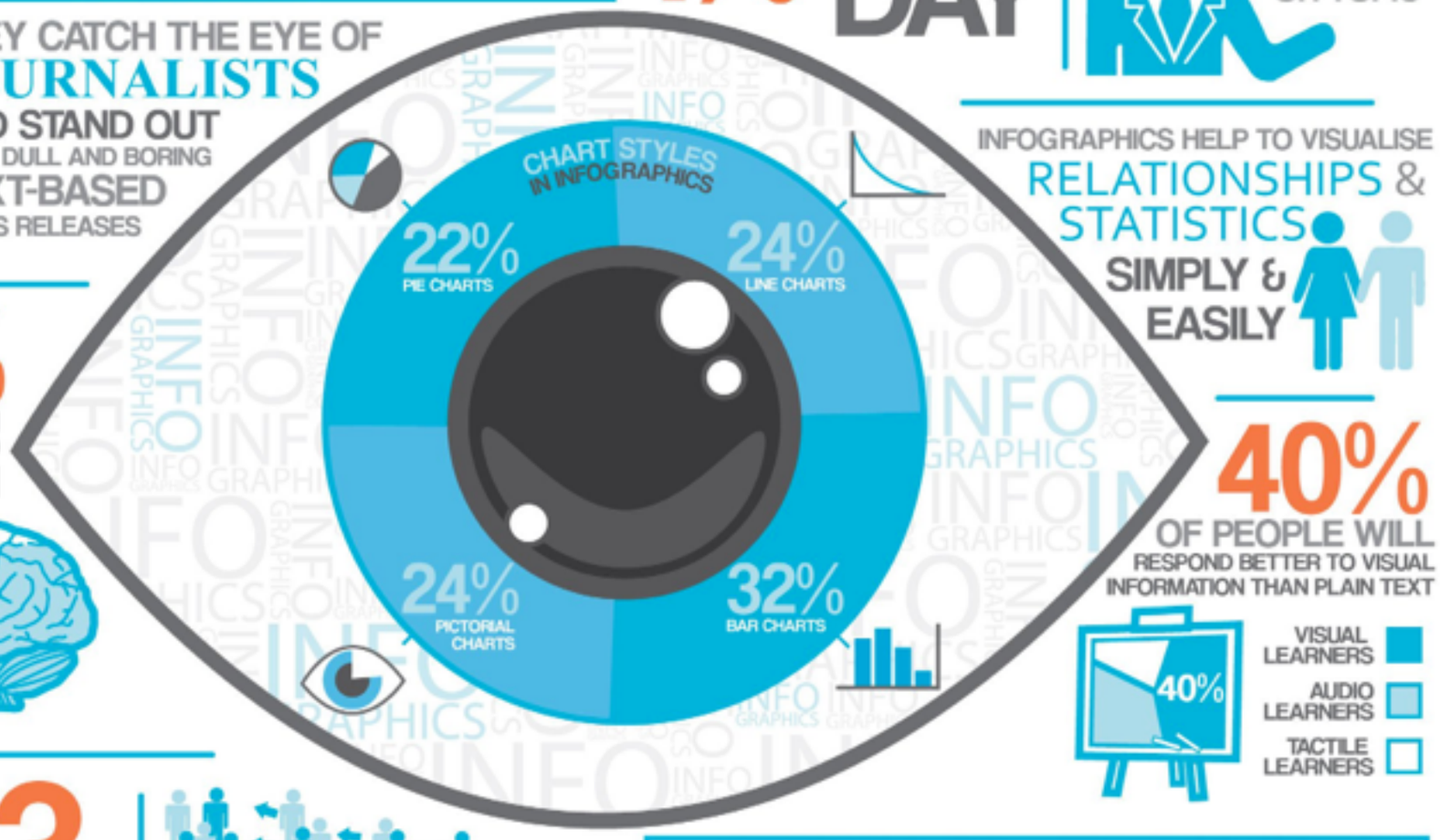
100% OF BUSINESSES CAN BENEFIT

EVERYONE SHOULD CONSIDER THE POTENTIAL ADVANTAGES RIGHT NOW

INFOGRAPHIC PRODUCTION INCREASES BY **1%** EVERY DAY

THEY SHOW AN **EXPERT** UNDERSTANDING OF A SUBJECT AREA OR TOPIC

THEY CATCH THE EYE OF **JOURNALISTS** AND STAND OUT FROM DULL AND BORING **TEXT-BASED** PRESS RELEASES



INFOGRAPHICS HELP TO VISUALISE **RELATIONSHIPS & STATISTICS** SIMPLY & EASILY

90% OF INFORMATION THAT COMES TO THE BRAIN IS **VISUAL**

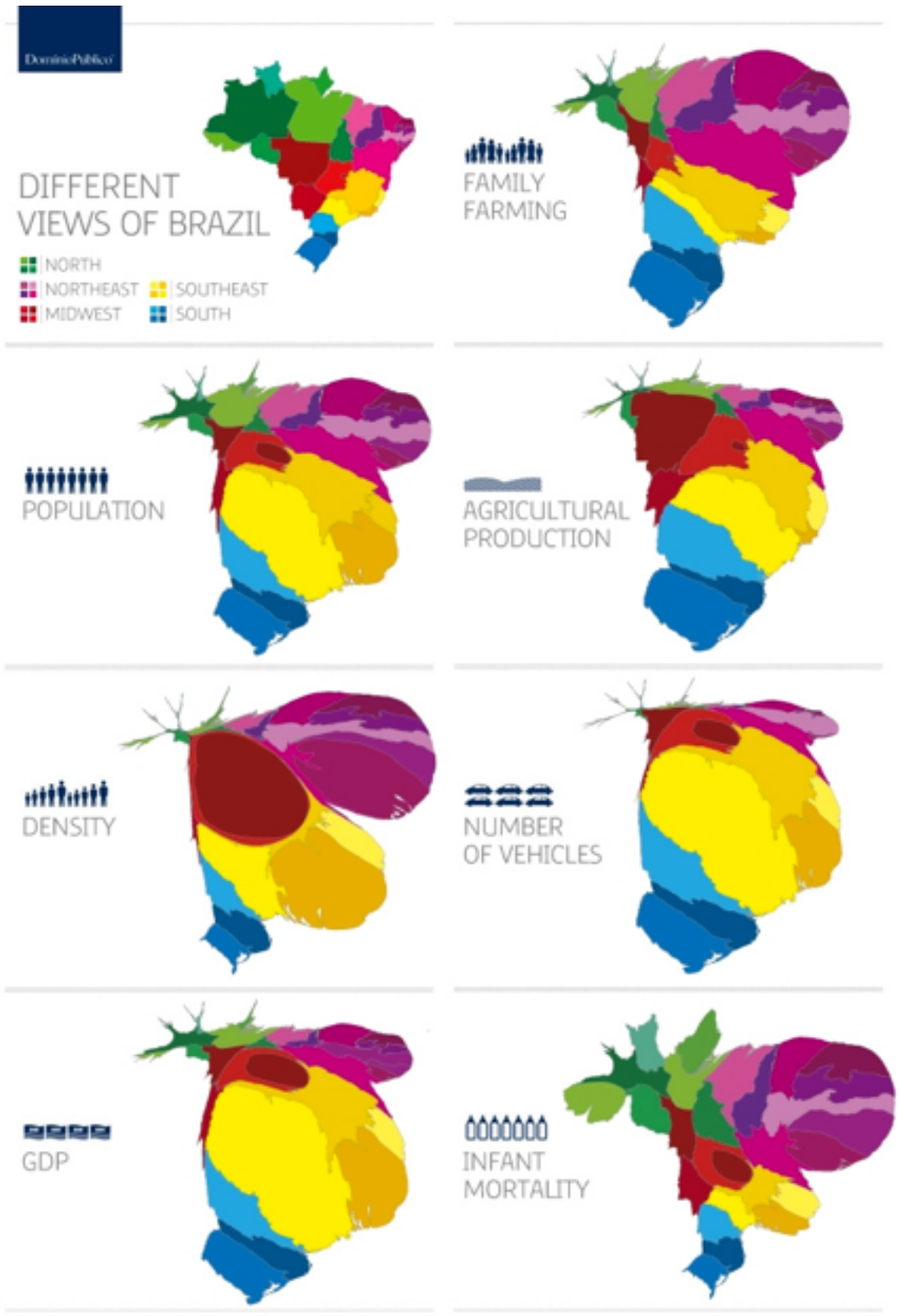
40% OF PEOPLE WILL RESPOND BETTER TO VISUAL INFORMATION THAN PLAIN TEXT

≈13 MILLION RESULTS FOR THE TERM 'INFOGRAPHIC' ON GOOGLE

INFOGRAPHICS **GO VIRAL**

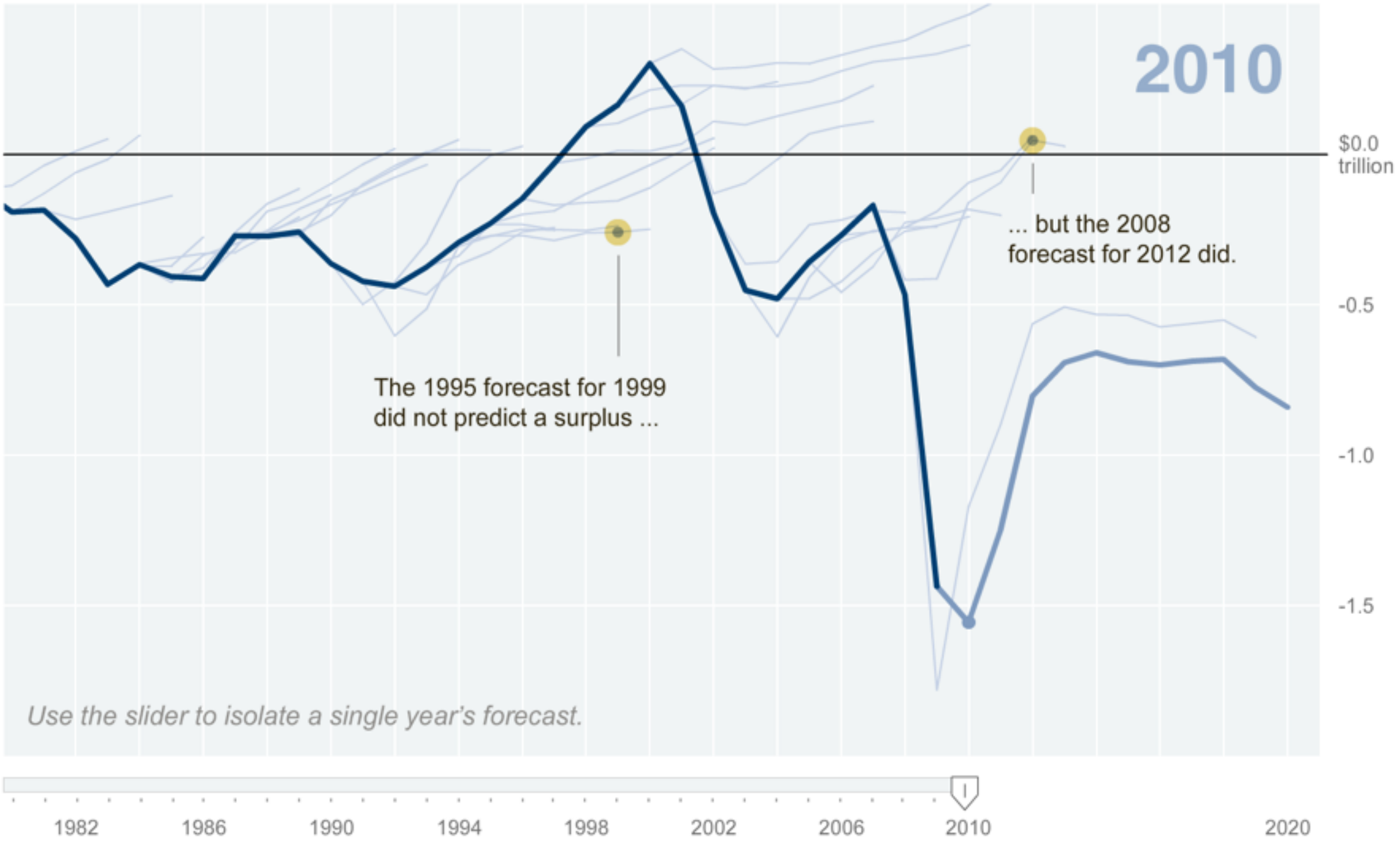
INFOGRAPHIC OF GRAPHICS

Effective?


DominioPublico
DIFFERENT
VIEWS OF BRAZIL
NORTH
NORTHEAST
SOUTHEAST
MIDWEST
SOUTH
FAMILY
FARMING
POPULATION
AGRICULTURAL
PRODUCTION
DENSITY
NUMBER
OF VEHICLES
GDP
INFANT
MORTALITY

Effective?

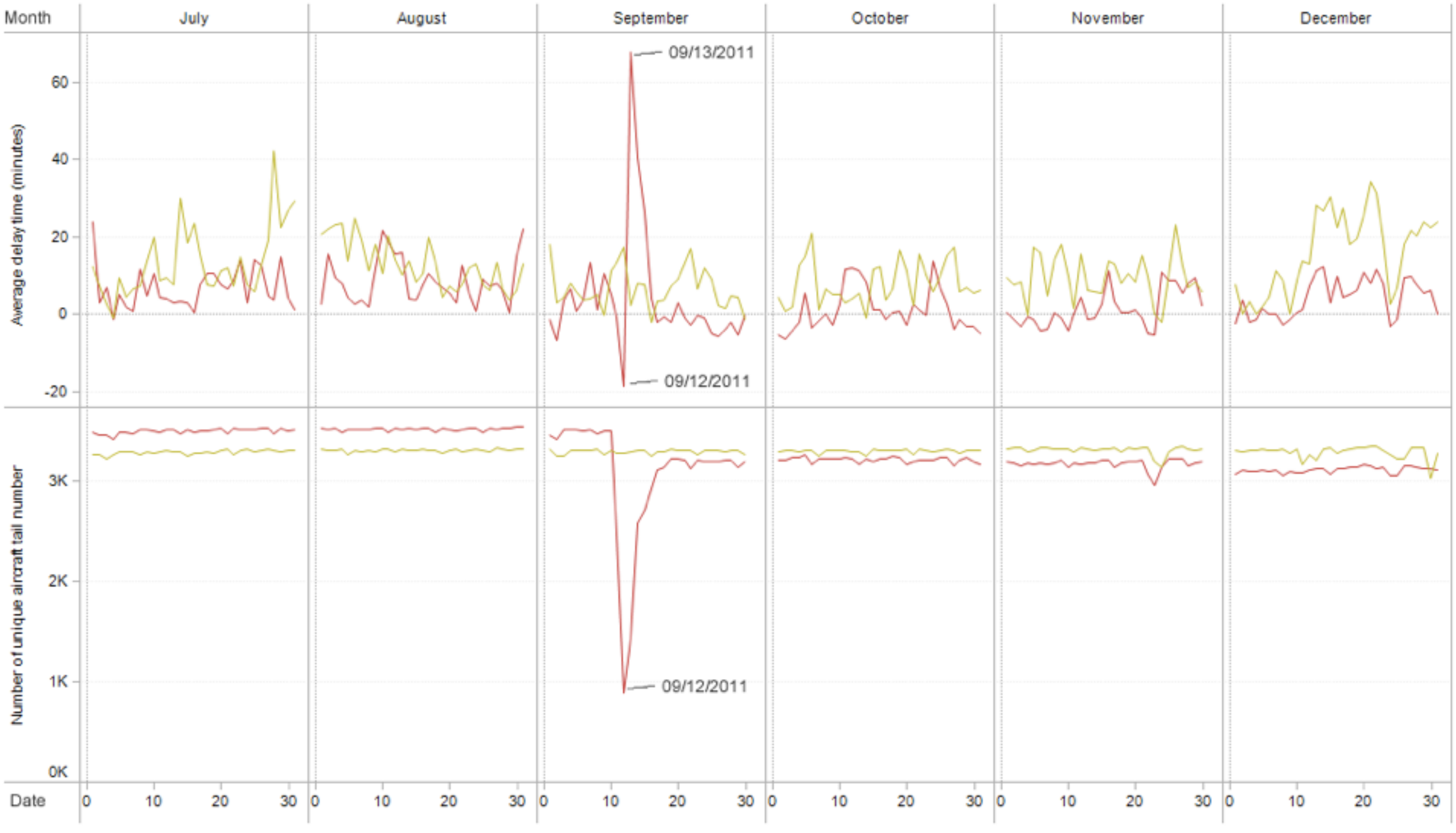
http://www.nytimes.com/interactive/2010/02/02/us/politics/20100201-budget-porcupine-graphic.html?_r=0



Effective?

Impact of 9/11 attacks on air traffic

Average flight delayed time [1] and the count of unique aircraft tail number [2] between July and December in 2000 vs 2001

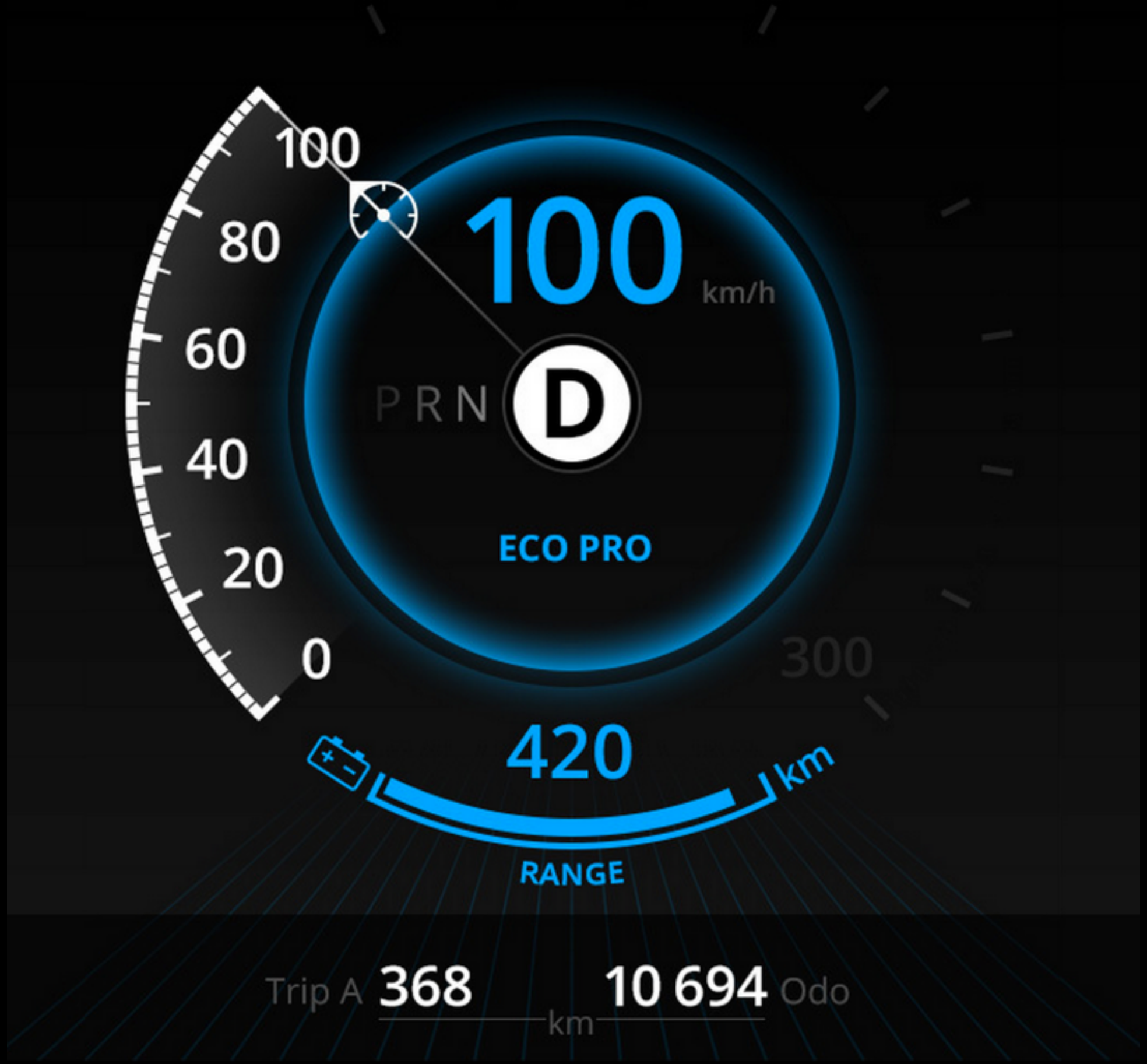


[1] Deplayed time is the difference between the actual arrival time in minutes.
Note that the delayed time is negative when aircraft arrives ealier than expected.

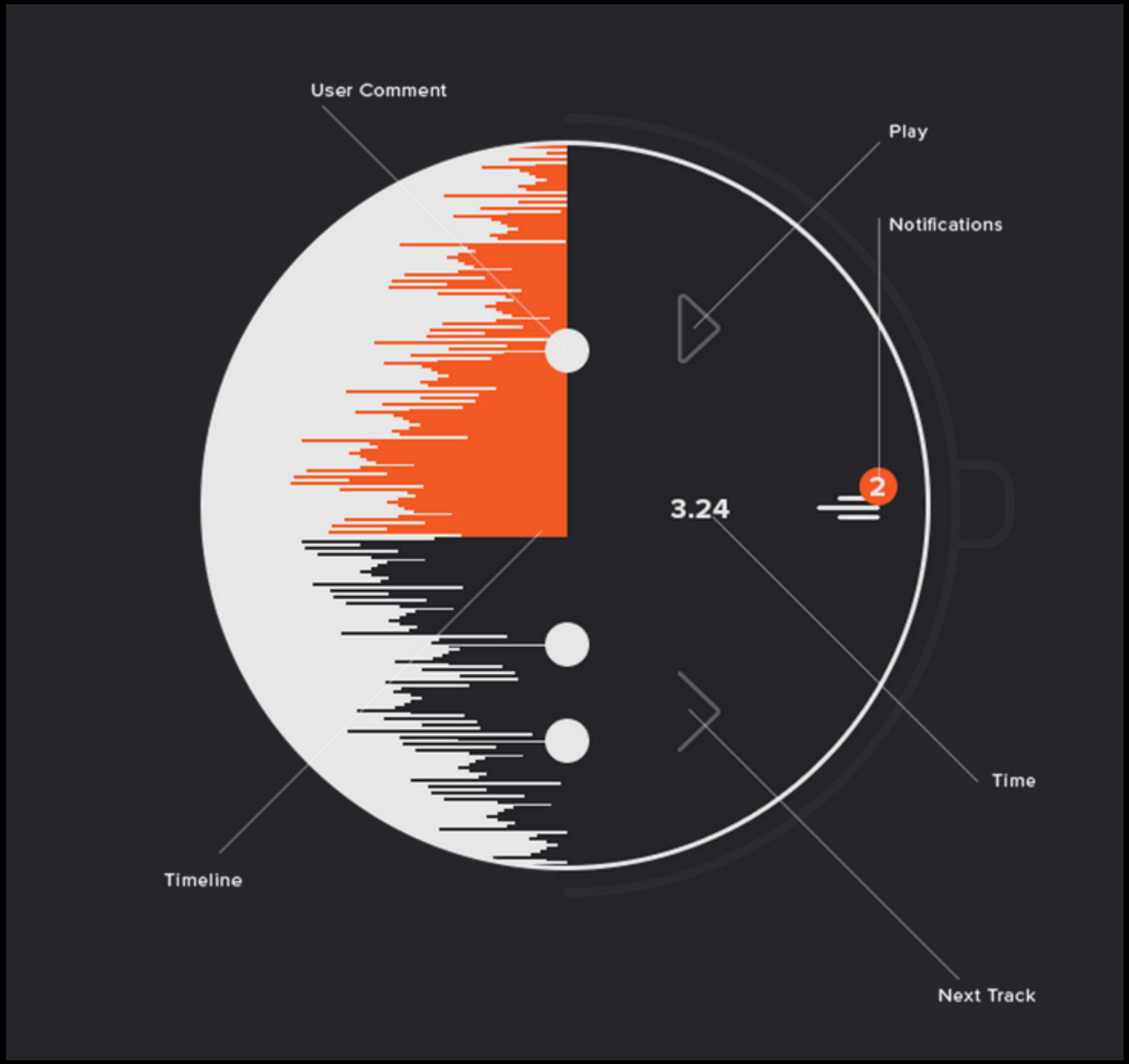
[2] A tail number refers to an unique identification number painted on an aircraft

10:05 o'clock

75% of goal


100
80
60
40
20
0
100
km/h
P R N D
ECO PRO
300
420
km
RANGE
Trip A 368 km
10 694 Odo


Banbury Dr
19th Ave
Gonzalez Dr
Cardenas Ave
Densiowe Dr
19th Ave
Holloway Ave
Varela Ave
Serrano Dr
100
80
60
40
20
0
100
km/h
P R N D
ECO PRO
420
km
RANGE
300
Trip
Phone
Entertainment
Energy consumption
Max 814
⌀ 331
Wh/km
0
+290
Past 100 km
19th Ave
Trip A 368 km
10 694 Odo
18:35
Thu, Sep 12
20°C


User Comment
Play
Notifications
2
3.24
Time
Timeline
Next Track

SoundCloud & Android Wear

Thanks to **@Mikael Eldenberg**
for the "Free Moto 360 Mockup"


1
6
34
Michał Galubiński udostępnił link:
Koniec Budki Suflera -
legendarna kapela twierdzi, że
1094
287
34

Some Basic Theory..

Goal

Understand how visualizations convey information What do people perceive/comprehend? How do visualizations correspond with mental models?

Develop principles and techniques for creating effective visualizations and supporting analysis Amplify perception and cognition Strengthen tie between visualization and mental models.

Data Model vs Conceptual Model
(1D float v Temperature)
(3D vector or floats v Space)

1D (set, sequence)
2D (maps)
3D (shapes)
nD (relational)
Trees (hierarchy)
Network (graphs)

Any more?

Nominal (labels), =,!=

Fruits: Apples, oranges; Example: bool, short, int32, float, double, string, ... Abstract types

Ordered, =, !=, < , >

Quality of meat: Grade A, AA, AAA, Provide descriptions of the data ;May be characterized by methods/attributes ; May be organized into a hierarchy

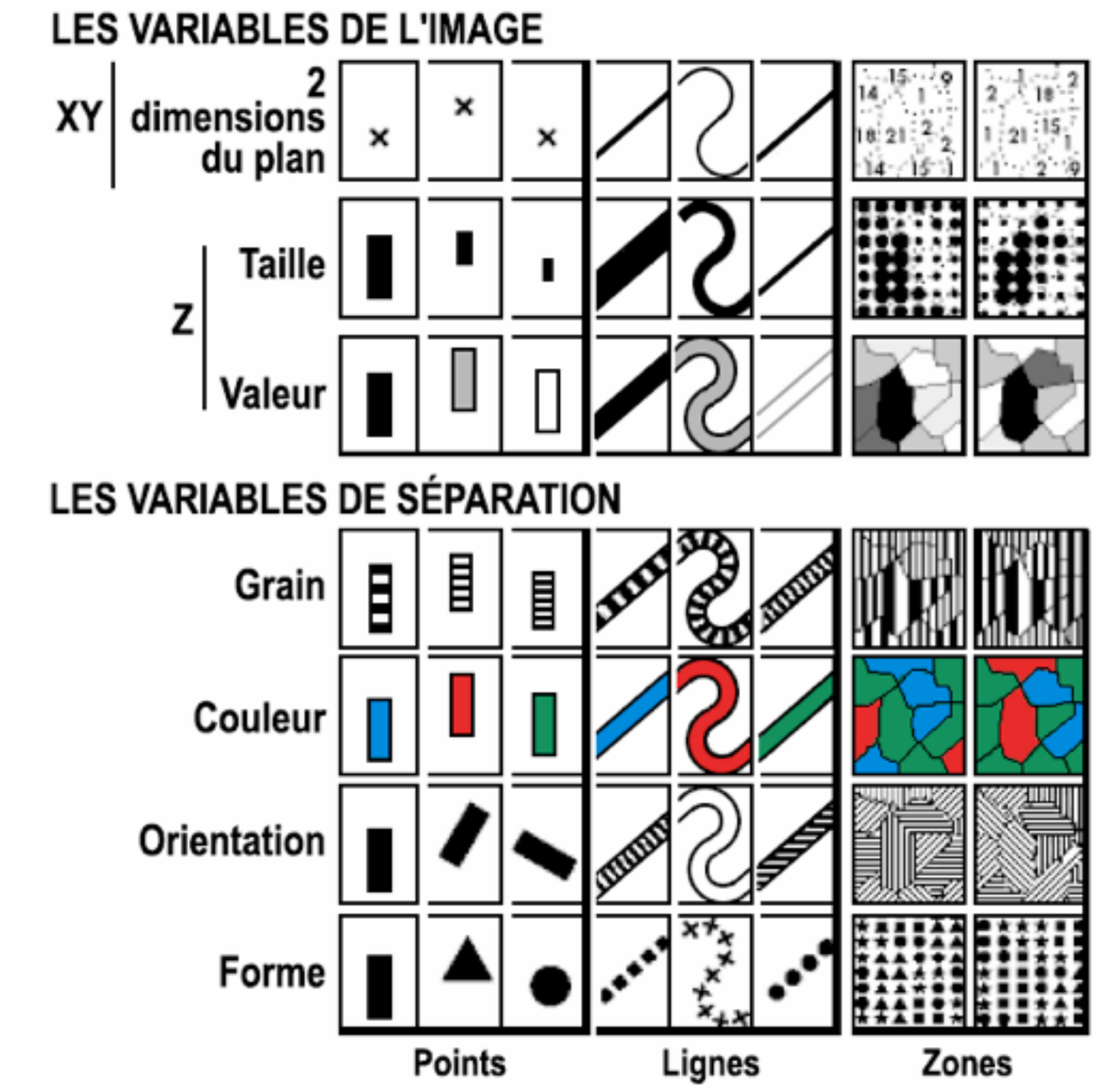
Interval (Location of zero arbitrary), =, !=, <, >, -

Like a geometric point. Cannot compare directly; Only differences (i.e. intervals) may be compared. Example: plants, animals, metazoans, ...

Ratio (zero fixed), =, !=, <, >, -, +

Physical measurement: Length, Mass, Temp, ... Counts and amounts; Like a geometric vector, origin is meaningful

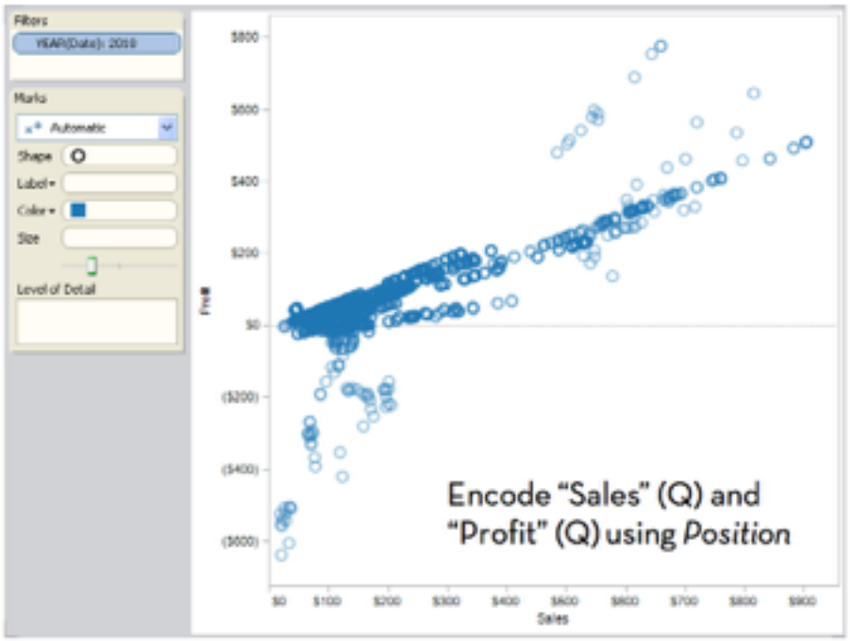
Data transformations (sql)
Projection (select)
Selection (where)
Sorting (order by)
Aggregation (group by, sum, min..)
Set operations (union, ...)
Combine (inner join, outer join, ...)

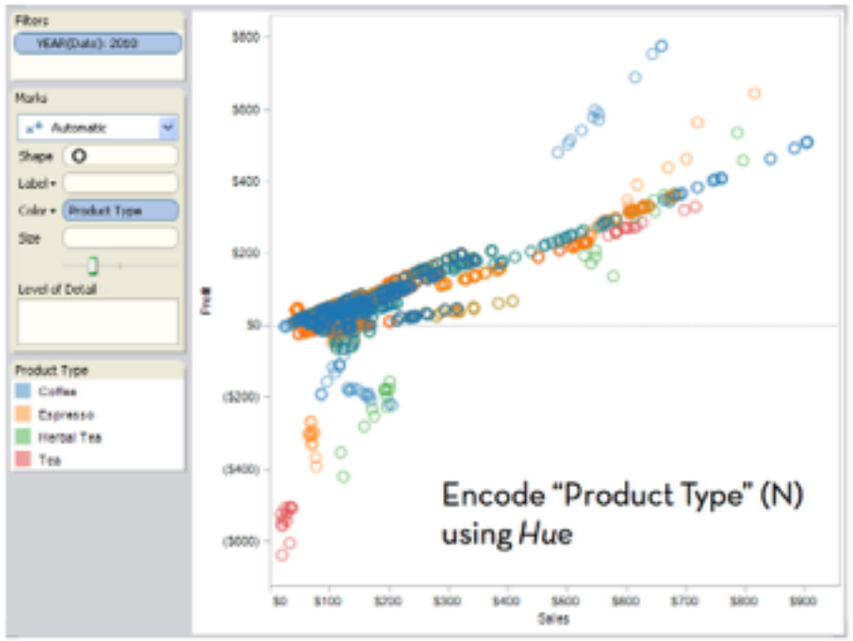


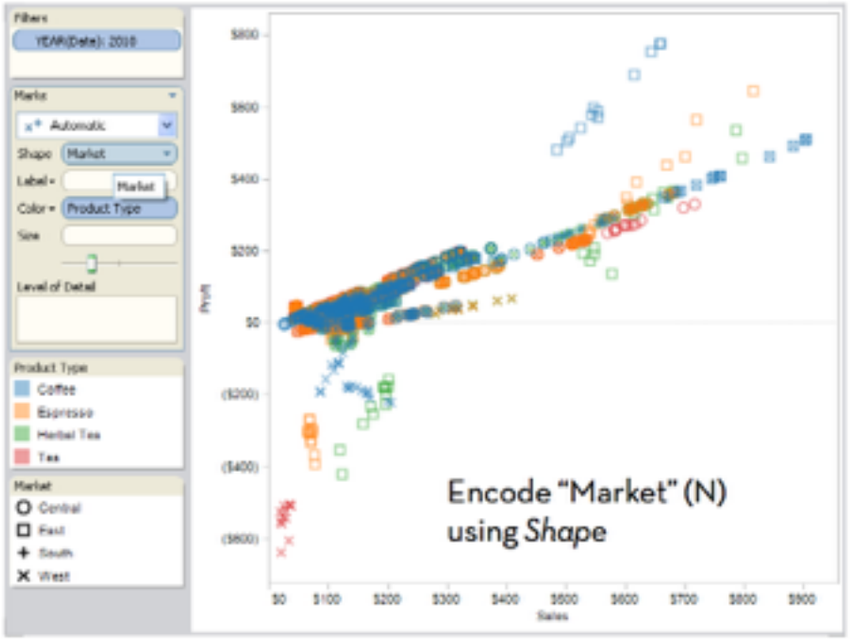
Position, Size, Value, Texture, Color, Orientation, Shape, more?

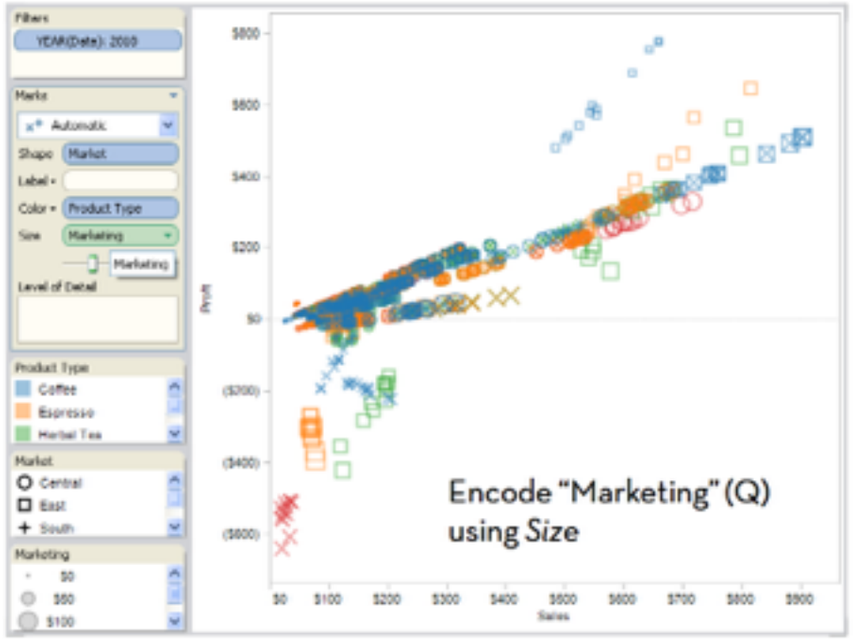
Transparency, blur/focus?

Multi Dimensional Data

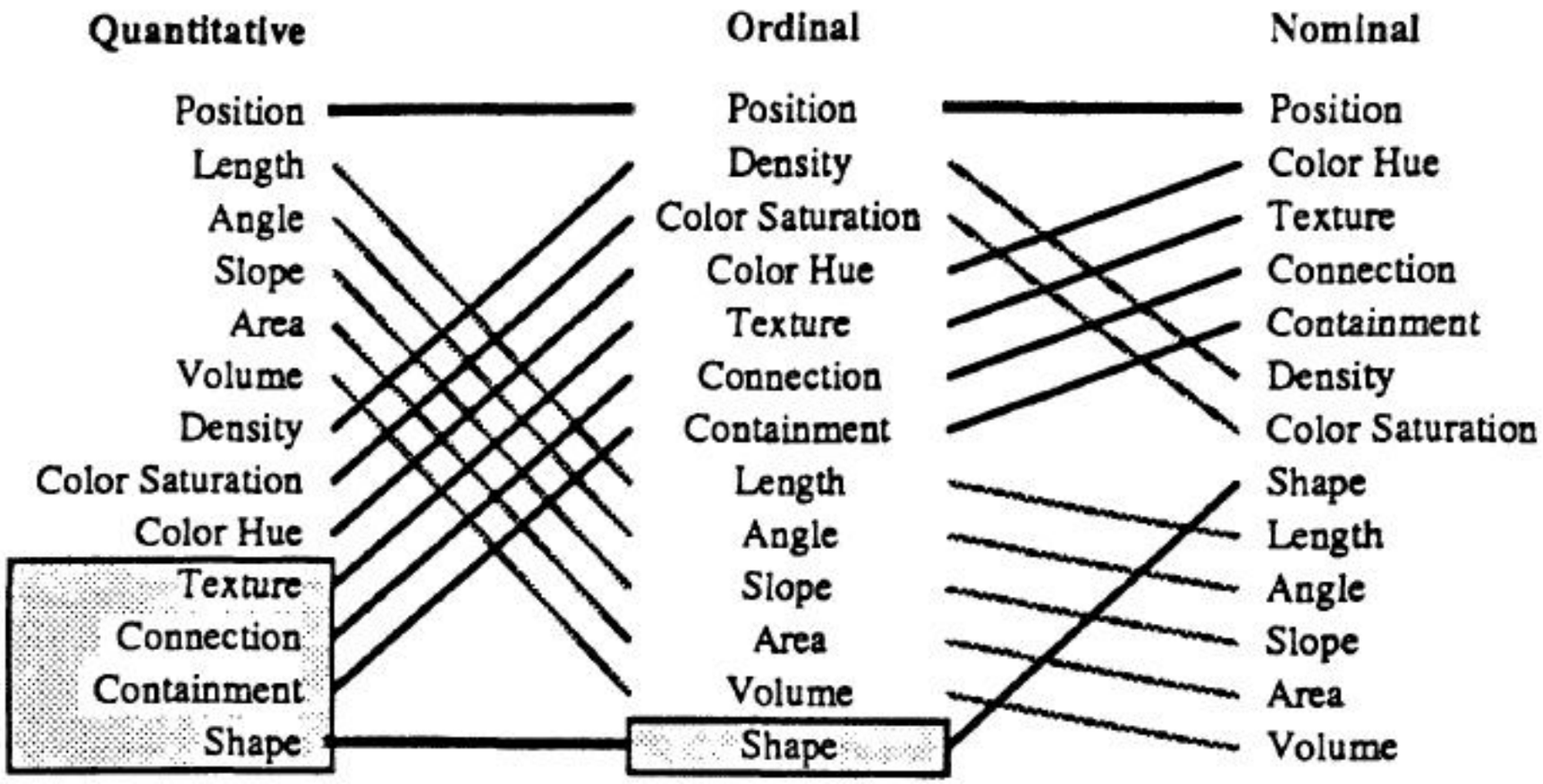






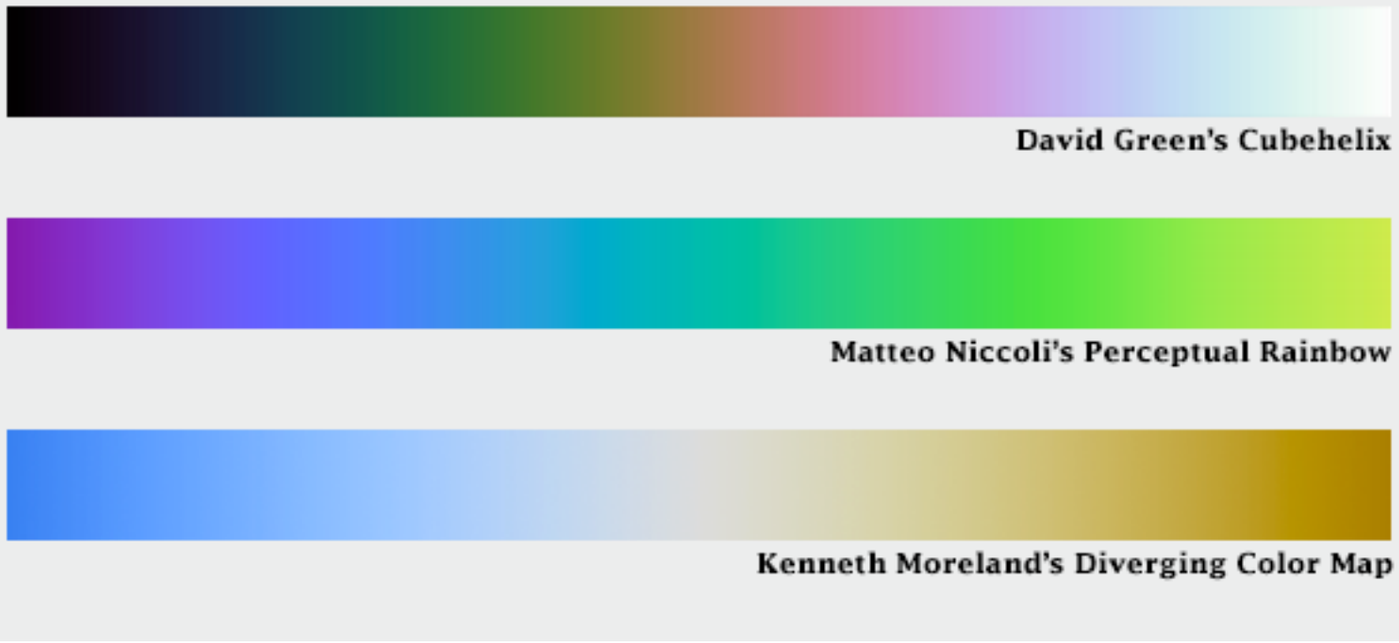


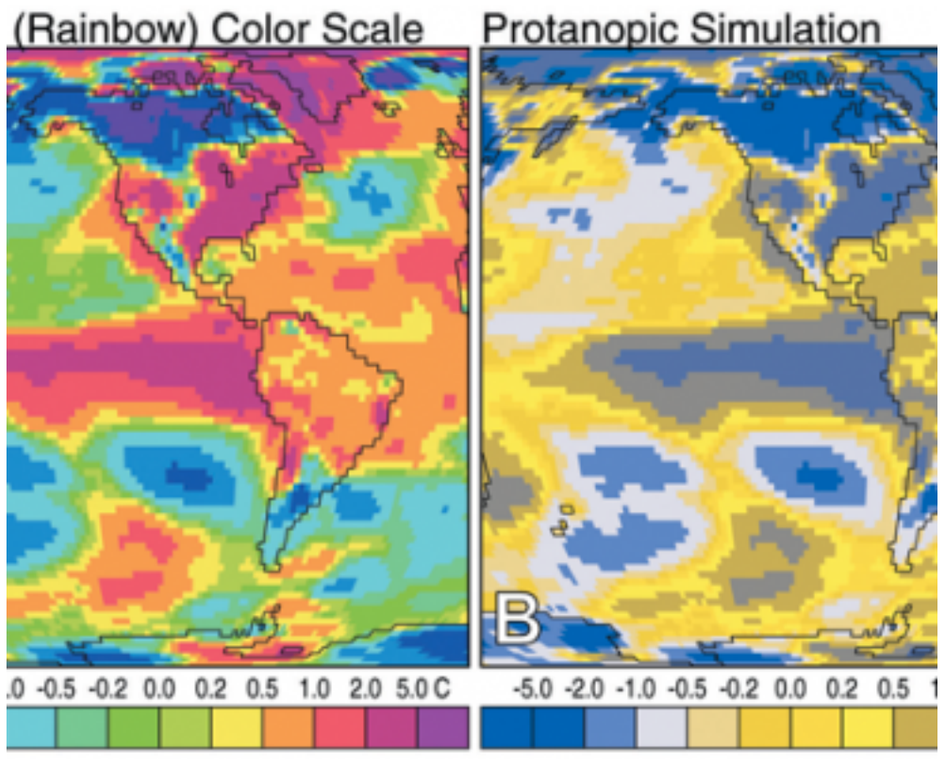
Mackinlay's Ranking

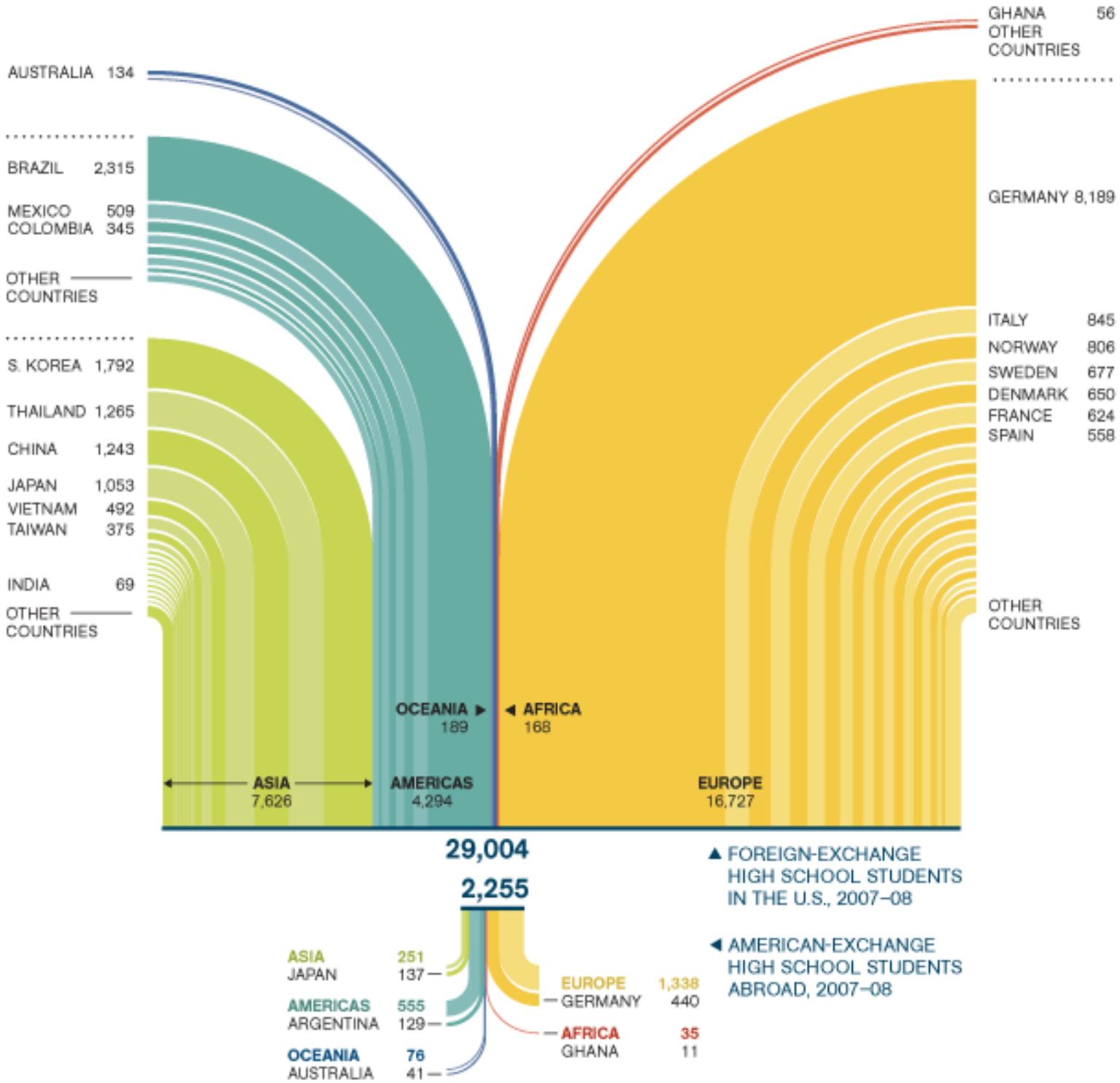


Conjecture of effectiveness in visual encoding.

And it’s complicated

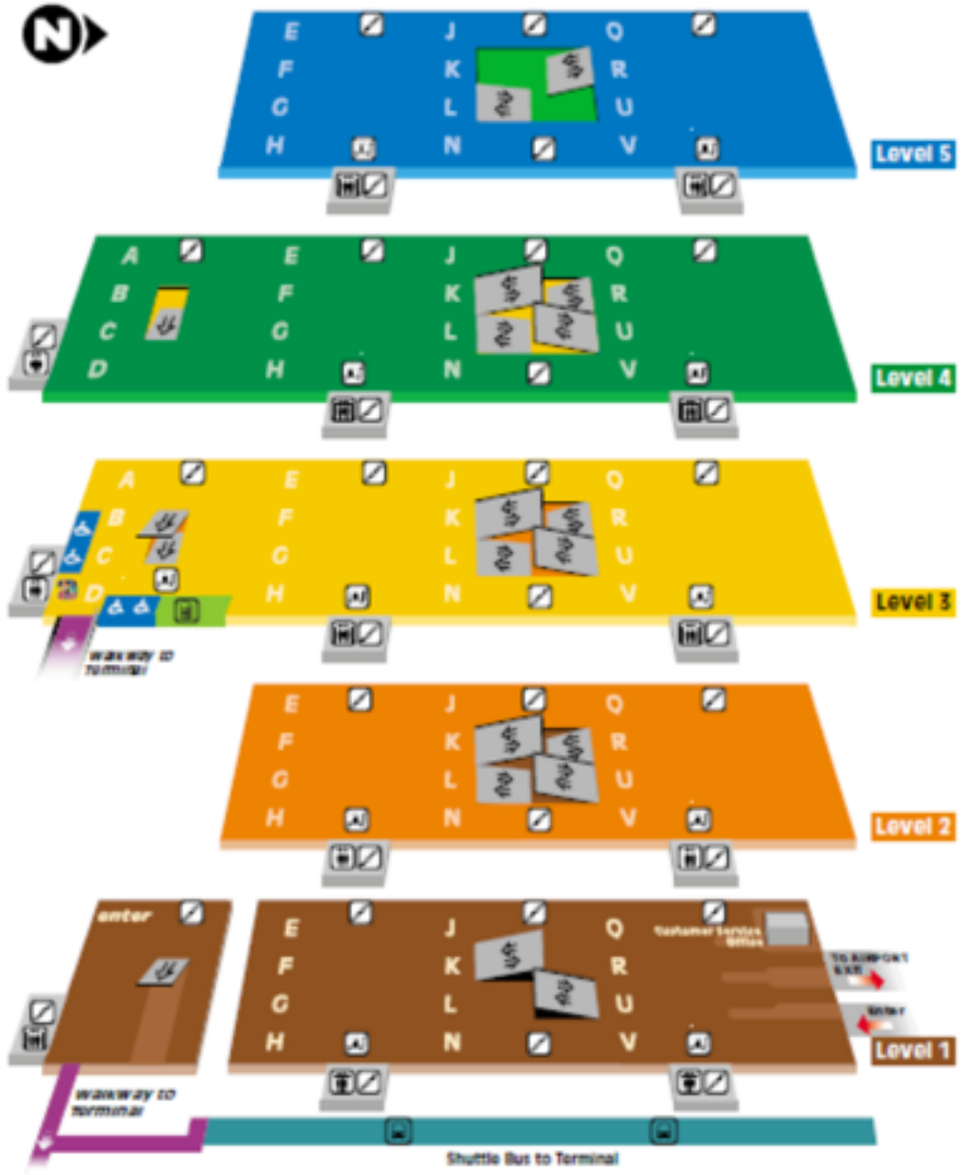



(Rainbow) Color Scale
Protanopic Simulation
B
.0 -0.5 -0.2 0.0 0.2 0.5 1.0 2.0 5.0 C
-5.0 -2.0 -1.0 -0.5 -0.2 0.0 0.2 0.5


AUSTRALIA 134
BRAZIL 2,315
MEXICO 509
COLOMBIA 345
OTHER COUNTRIES
S. KOREA 1,792
THAILAND 1,265
CHINA 1,243
JAPAN 1,053
VIETNAM 492
TAIWAN 375
INDIA 69
OTHER COUNTRIES
GHANA 56
OTHER COUNTRIES
GERMANY 8,189
ITALY 845
NORWAY 806
SWEDEN 677
DENMARK 650
FRANCE 624
SPAIN 558
OTHER COUNTRIES
OCEANIA ▶ 189
◀ AFRICA 168
ASIA 7,626
AMERICAS 4,294
EUROPE 16,727
29,004
2,255
ASIA 251
JAPAN 137
AMERICAS 555
ARGENTINA 129
OCEANIA 76
AUSTRALIA 41
EUROPE 1,338
GERMANY 440
AFRICA 35
GHANA 11
▲ FOREIGN-EXCHANGE HIGH SCHOOL STUDENTS IN THE U.S., 2007–08
◀ AMERICAN-EXCHANGE HIGH SCHOOL STUDENTS ABROAD, 2007–08

Daily Garage 2 Legend

- You are here
- Row
- Stairwell
- Elevator
- Pay and Go
- Shuttle Bus Pick-up/Drop-off
- Walkway to Terminal
- Luggage Cart Pick-up/Drop-off
- Ramp
- Electric vehicle Parking and Recharging stations only

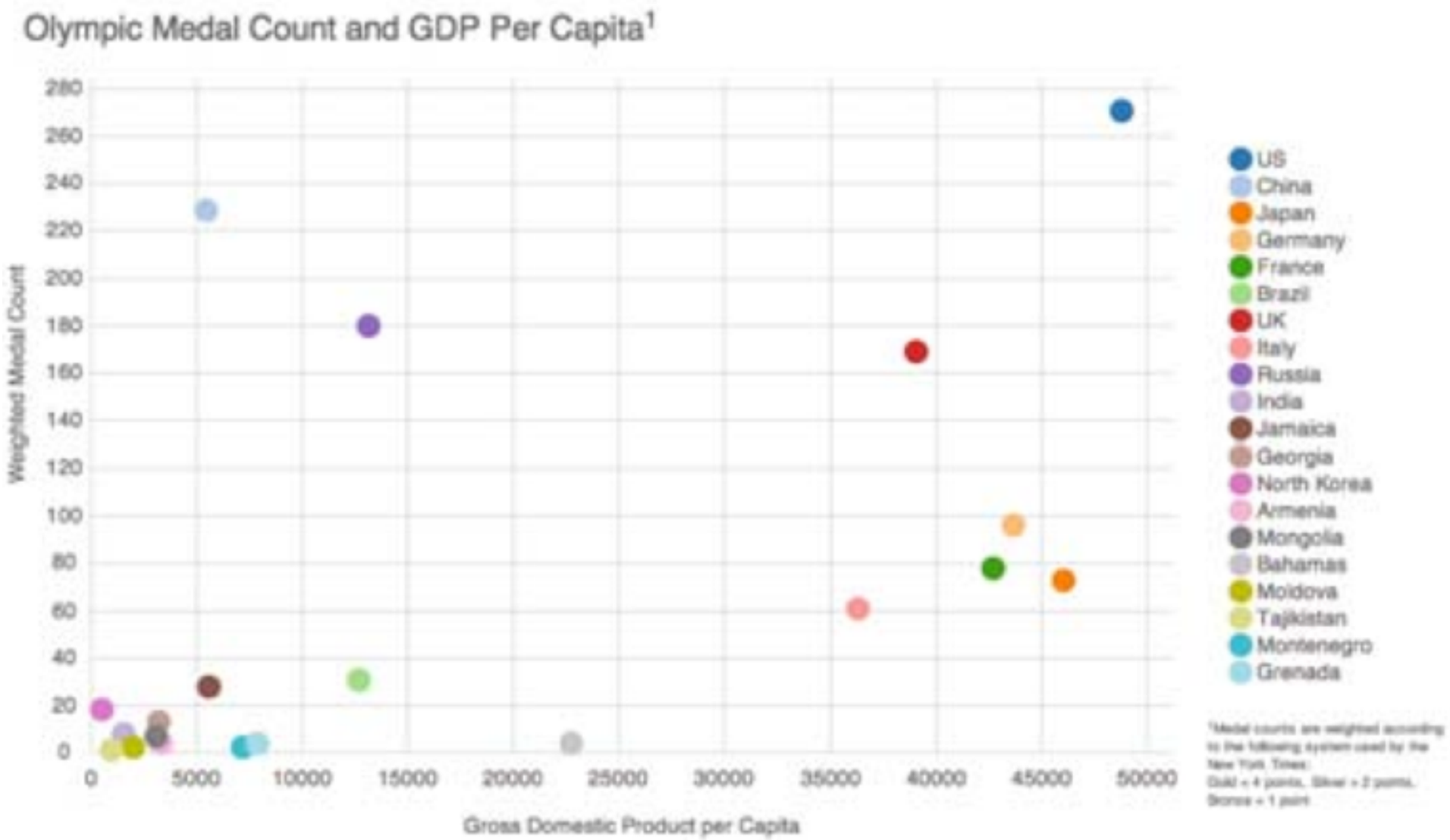


Take your parking ticket with you.
Pay for parking at Pay and Go machines.

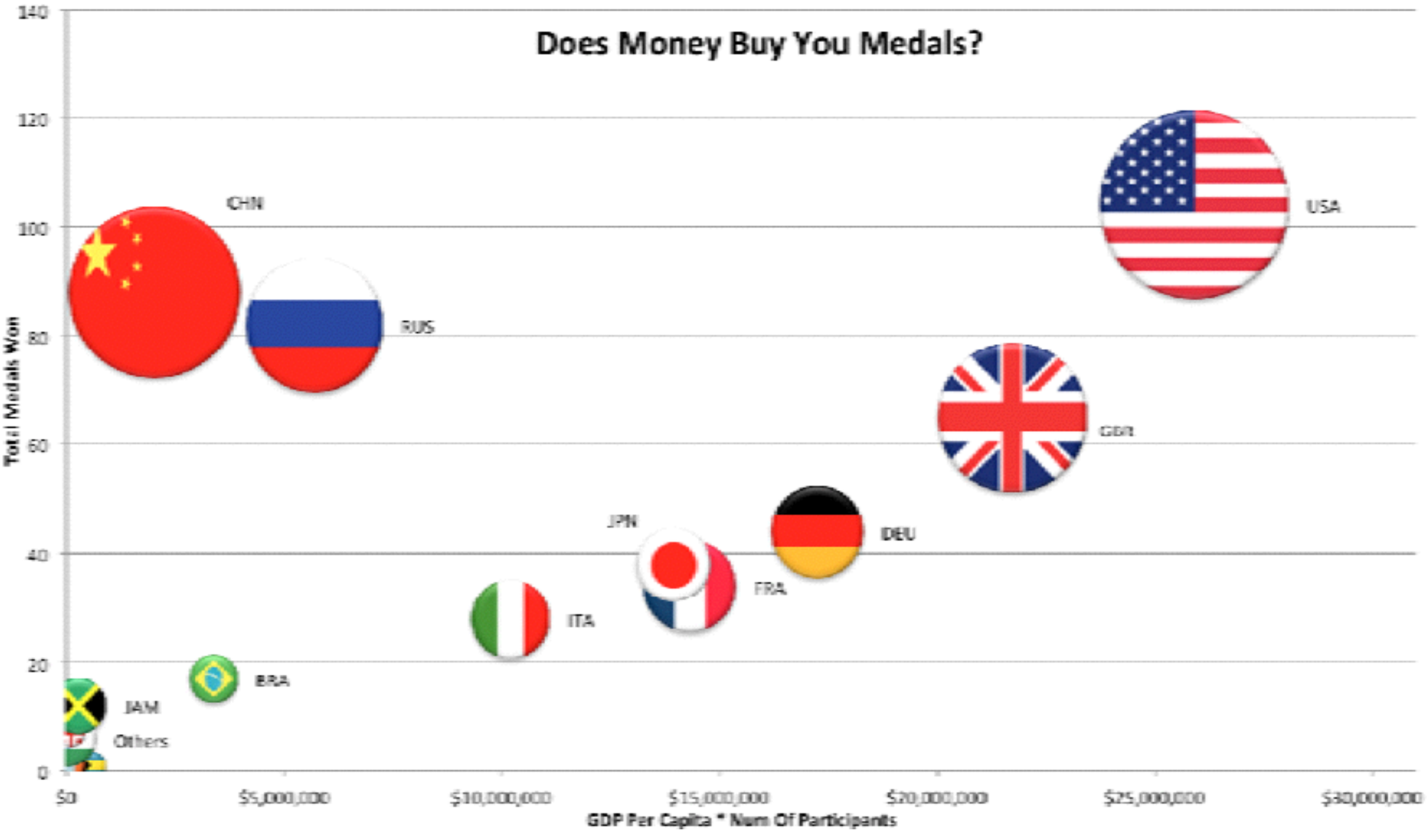
Map is current as of 3/2012

Charts

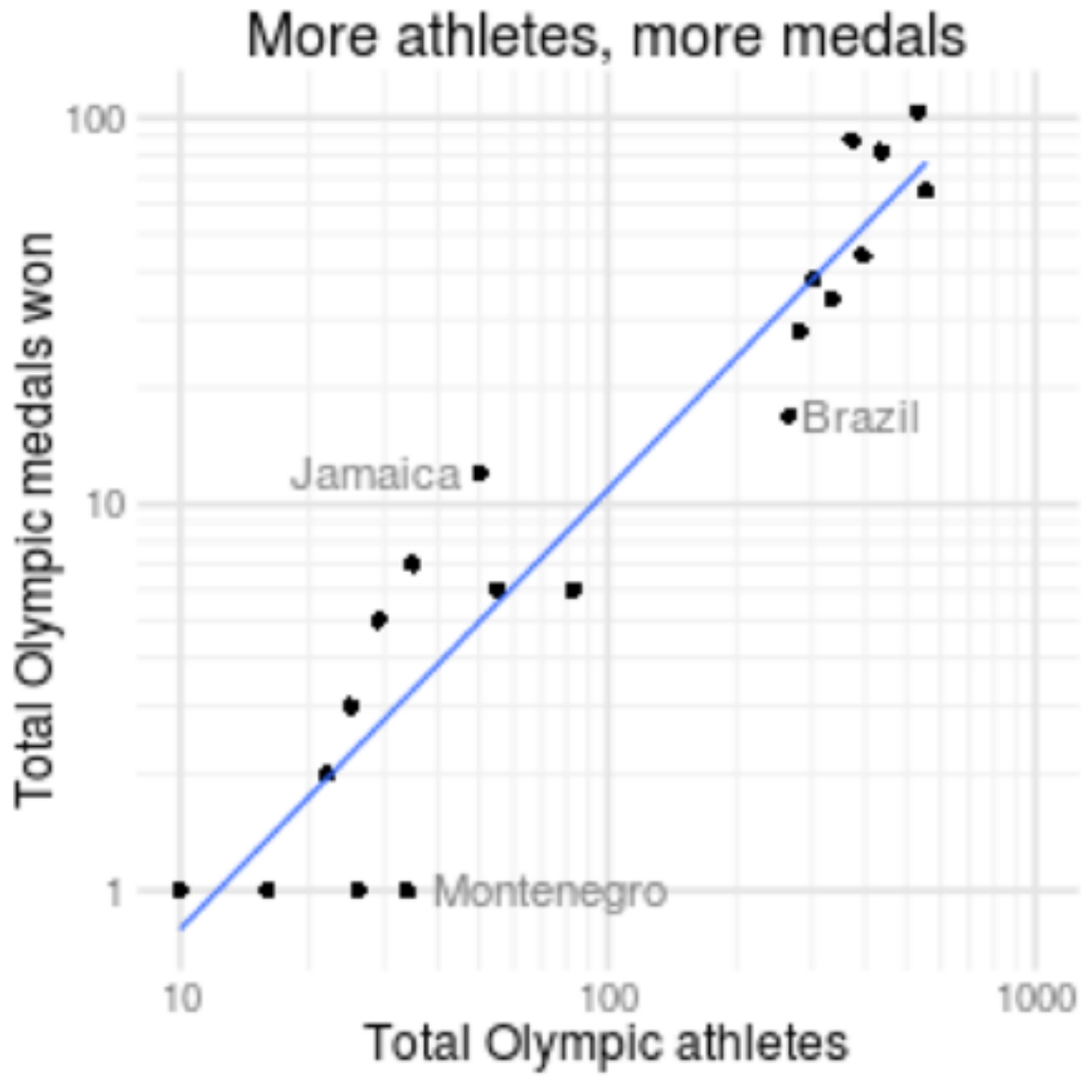
Scatter Plots



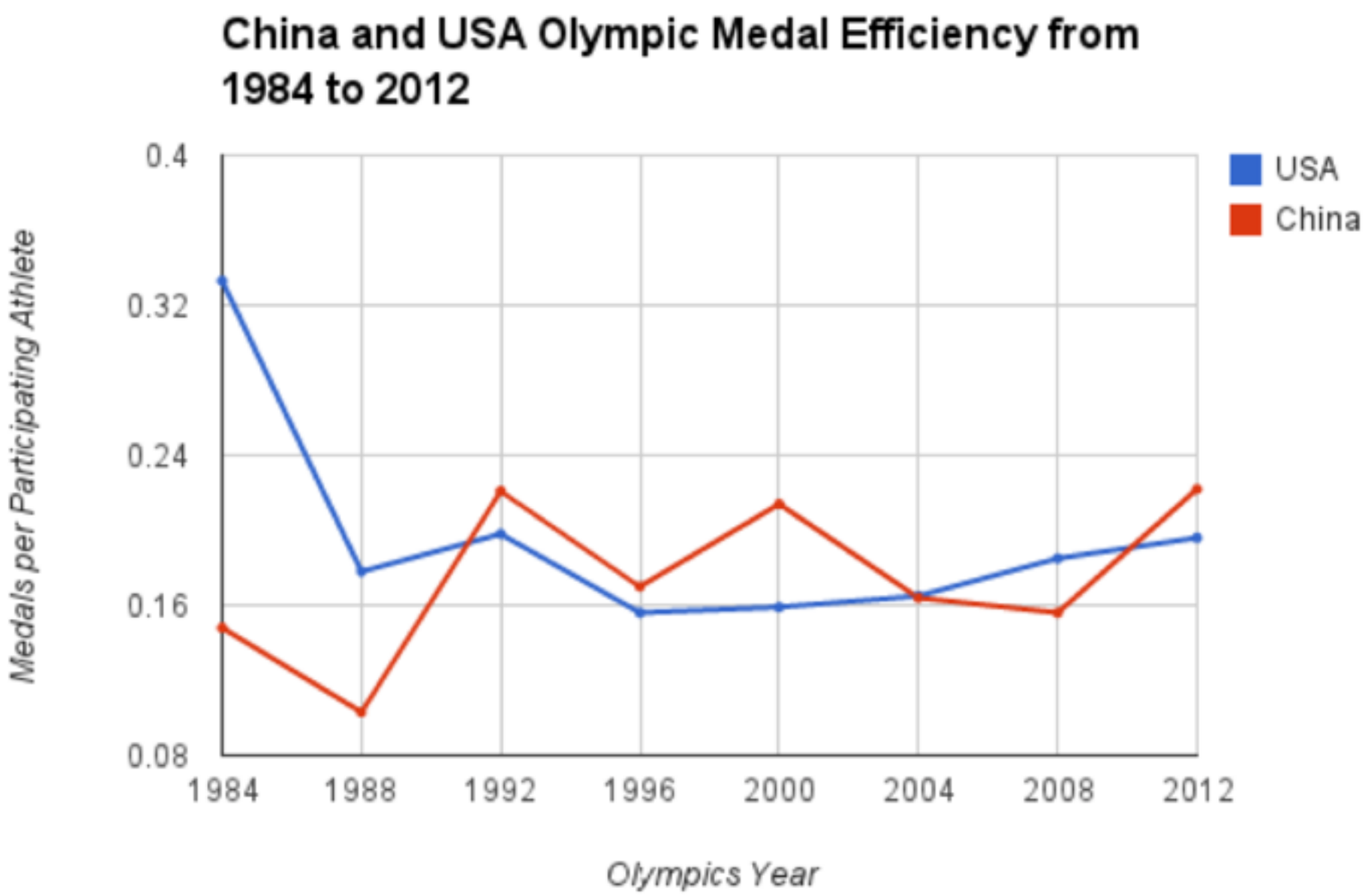
Scatter Plots



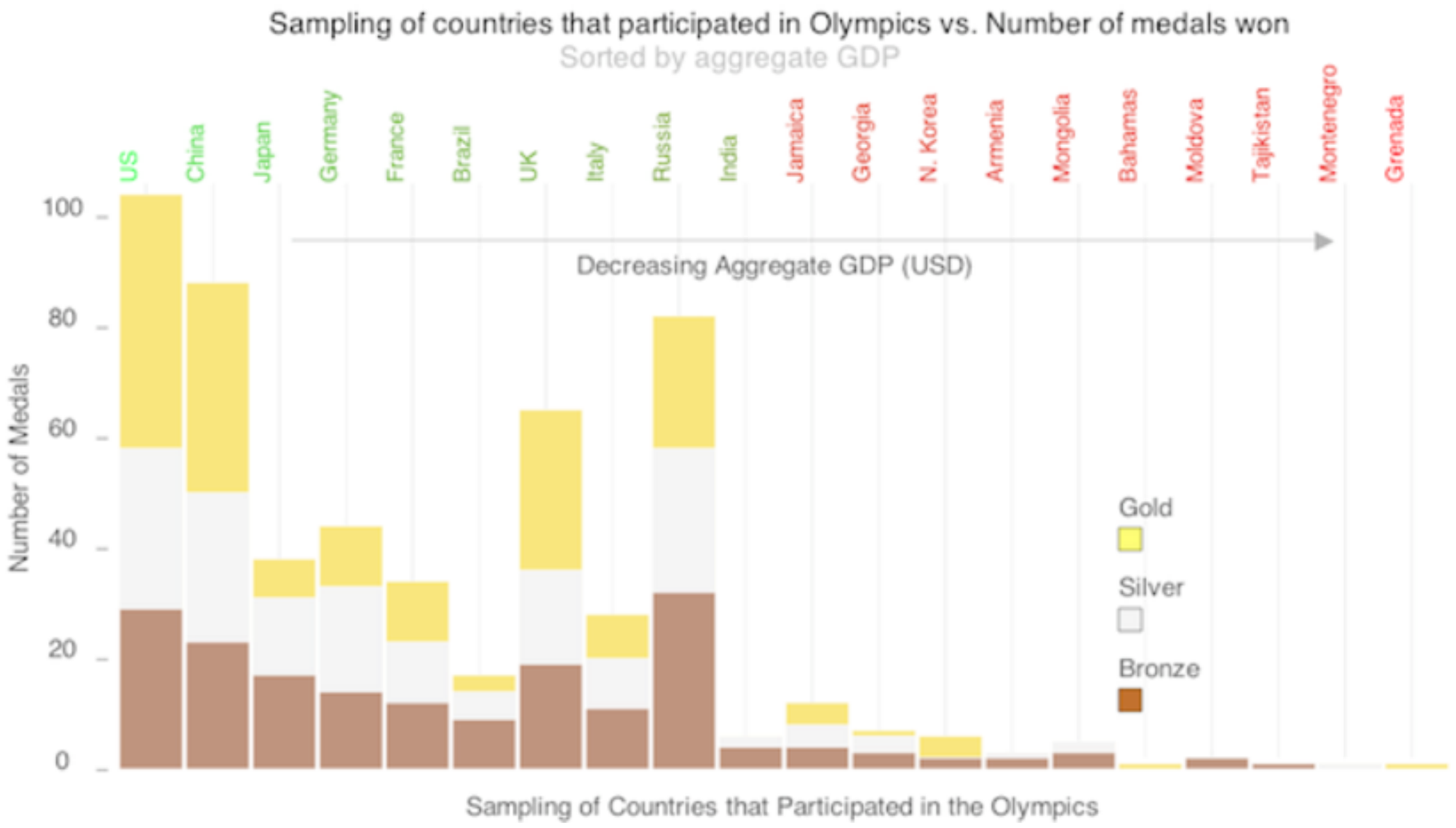
Fitness Line, multi charts



Line charts

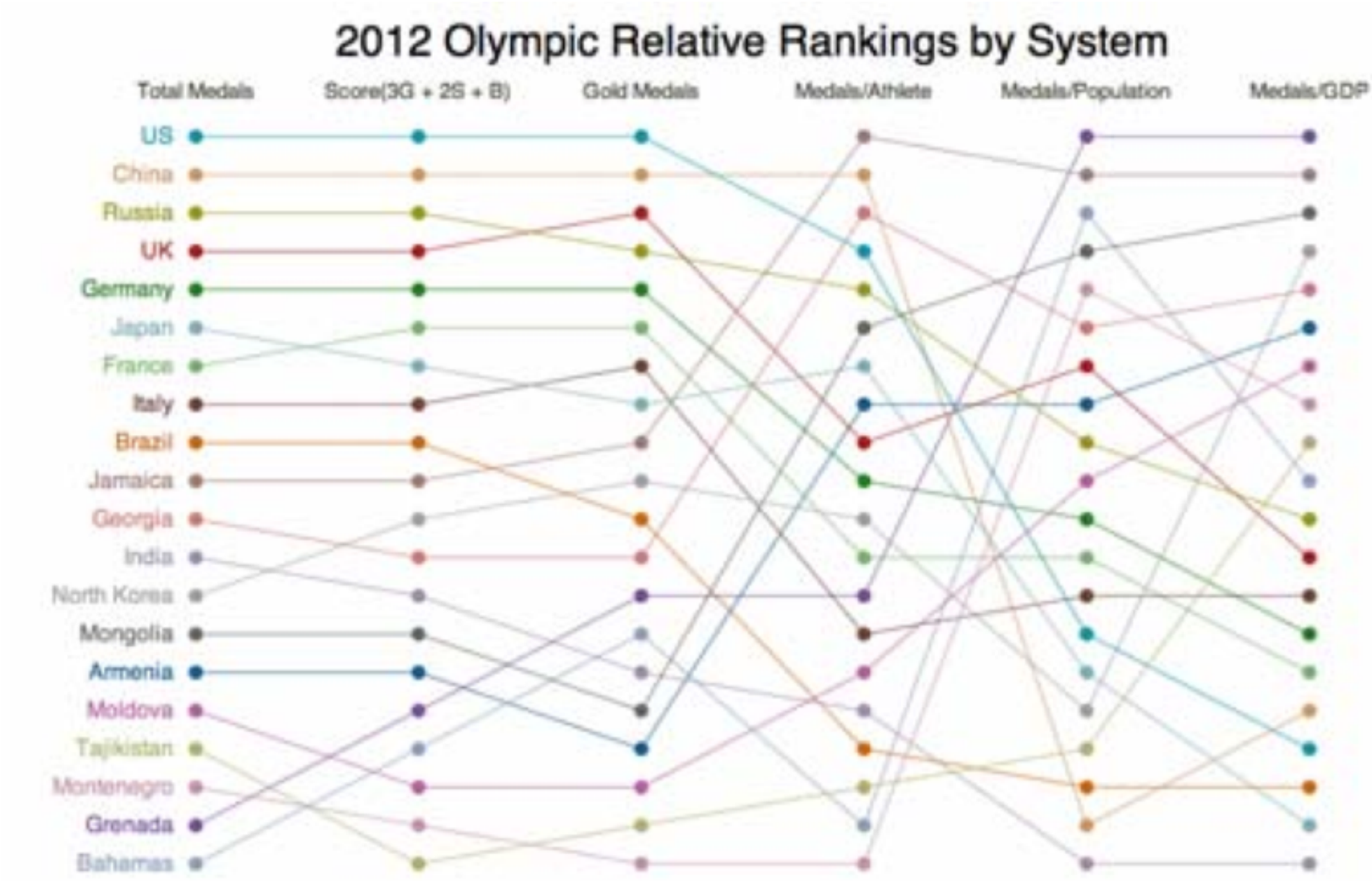

China and USA Olympic Medal Efficiency from 1984 to 2012
0.4
0.32
0.24
0.16
0.08
1984
1988
1992
1996
2000
2004
2008
2012
USA
China
Medals per Participating Athlete
Olympics Year

Stacked Bar Chart

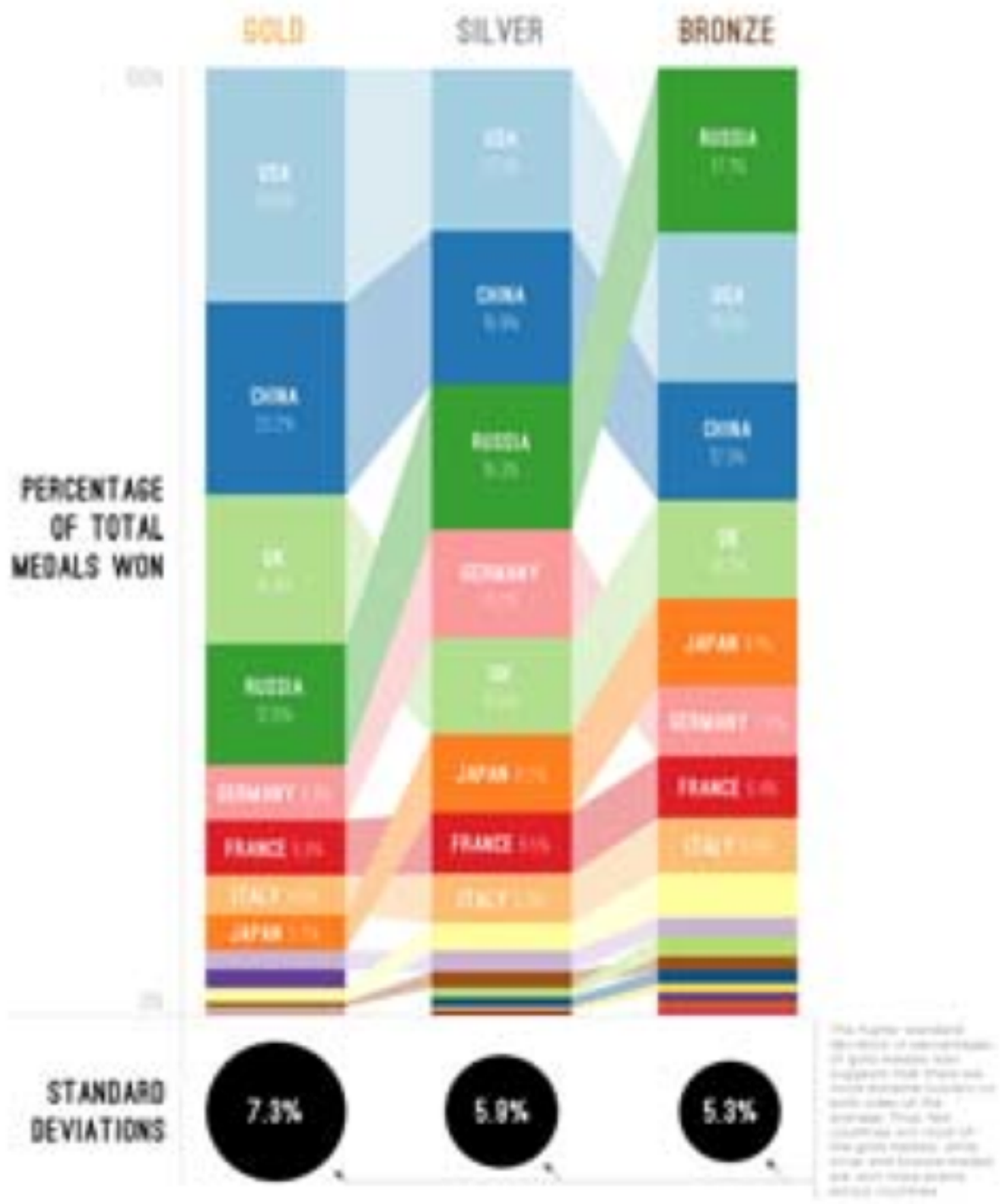


Stacked Bar Muti-Chart

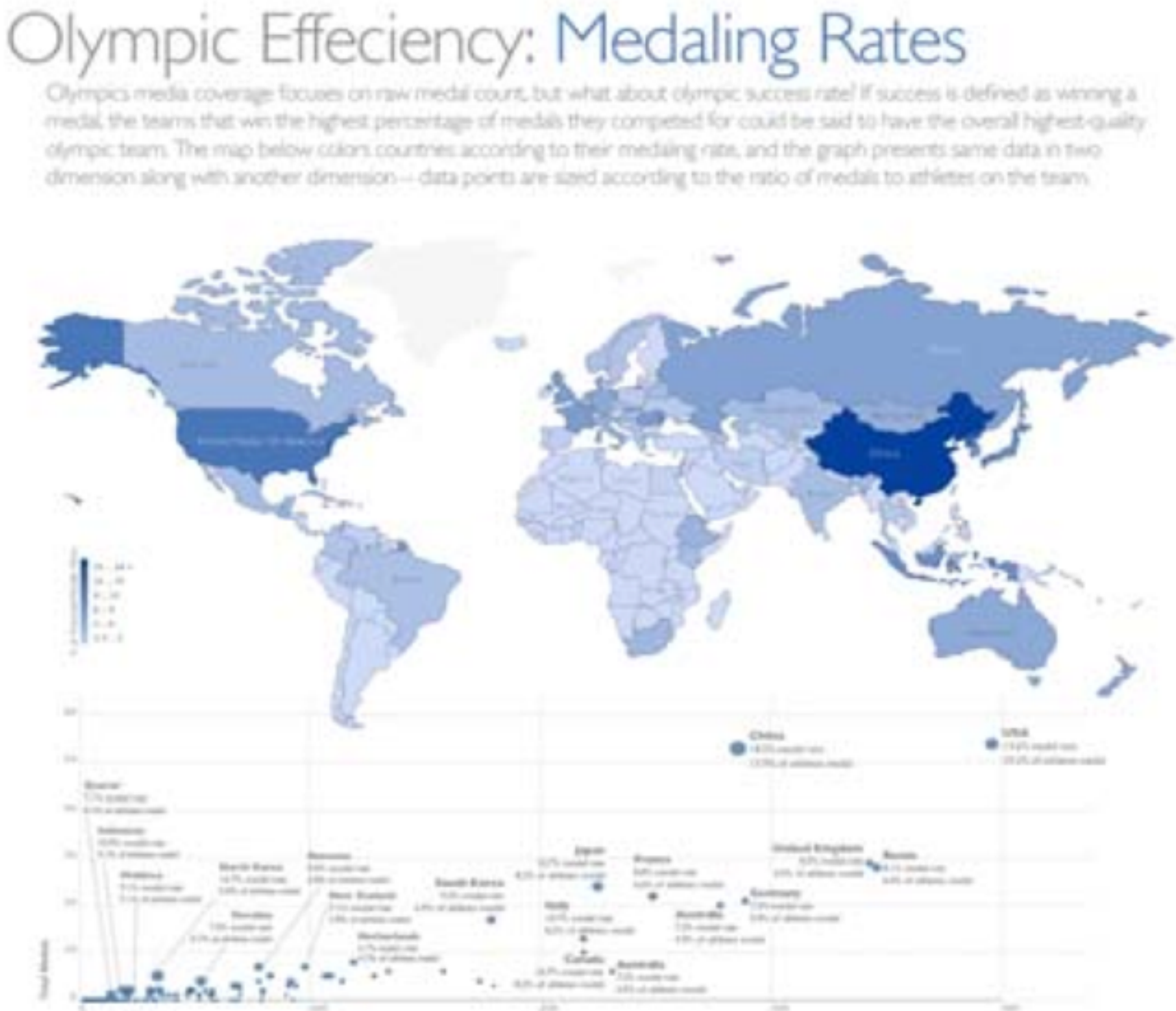
Parallel Coordinates



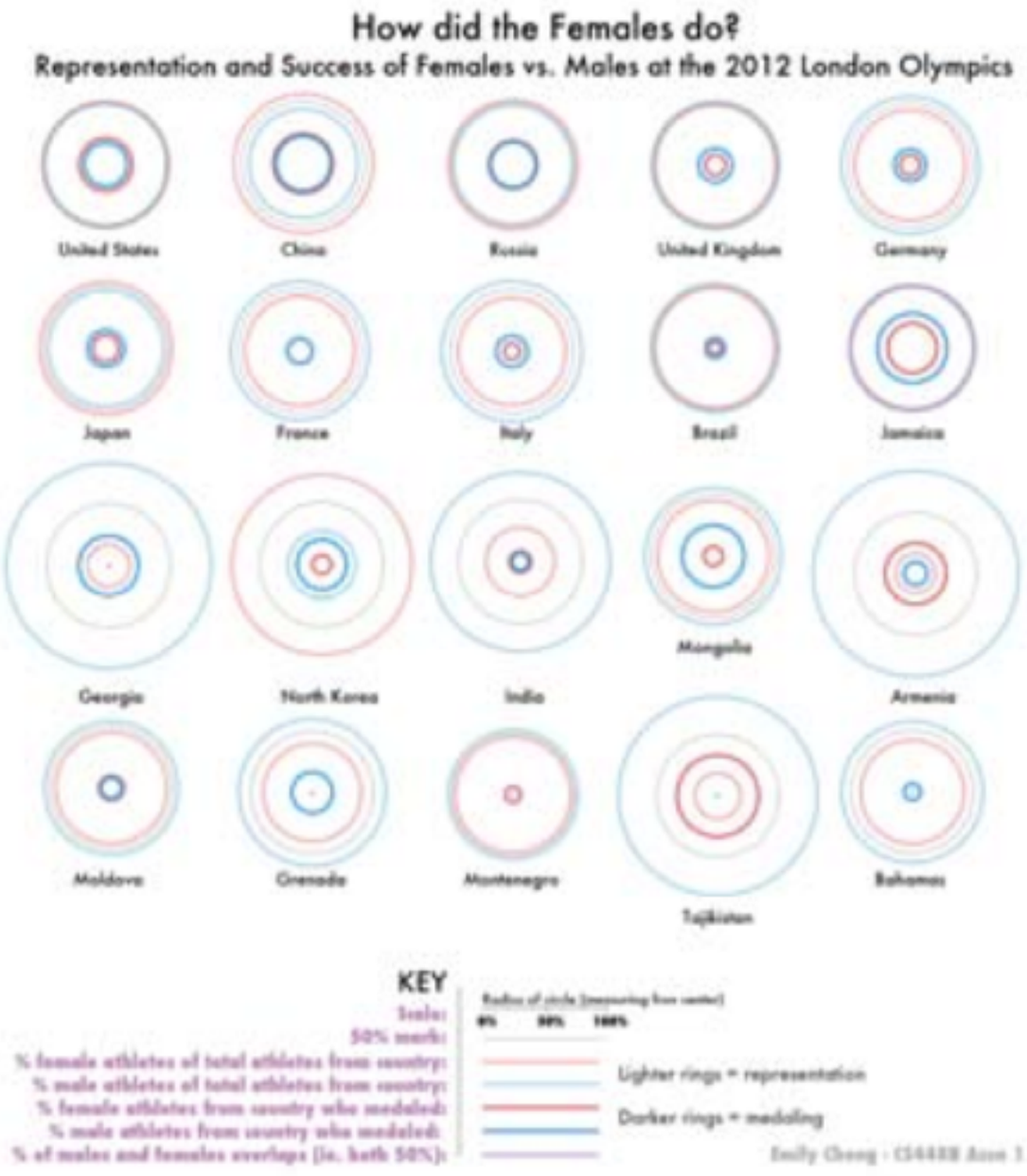
Parallel Coordinates



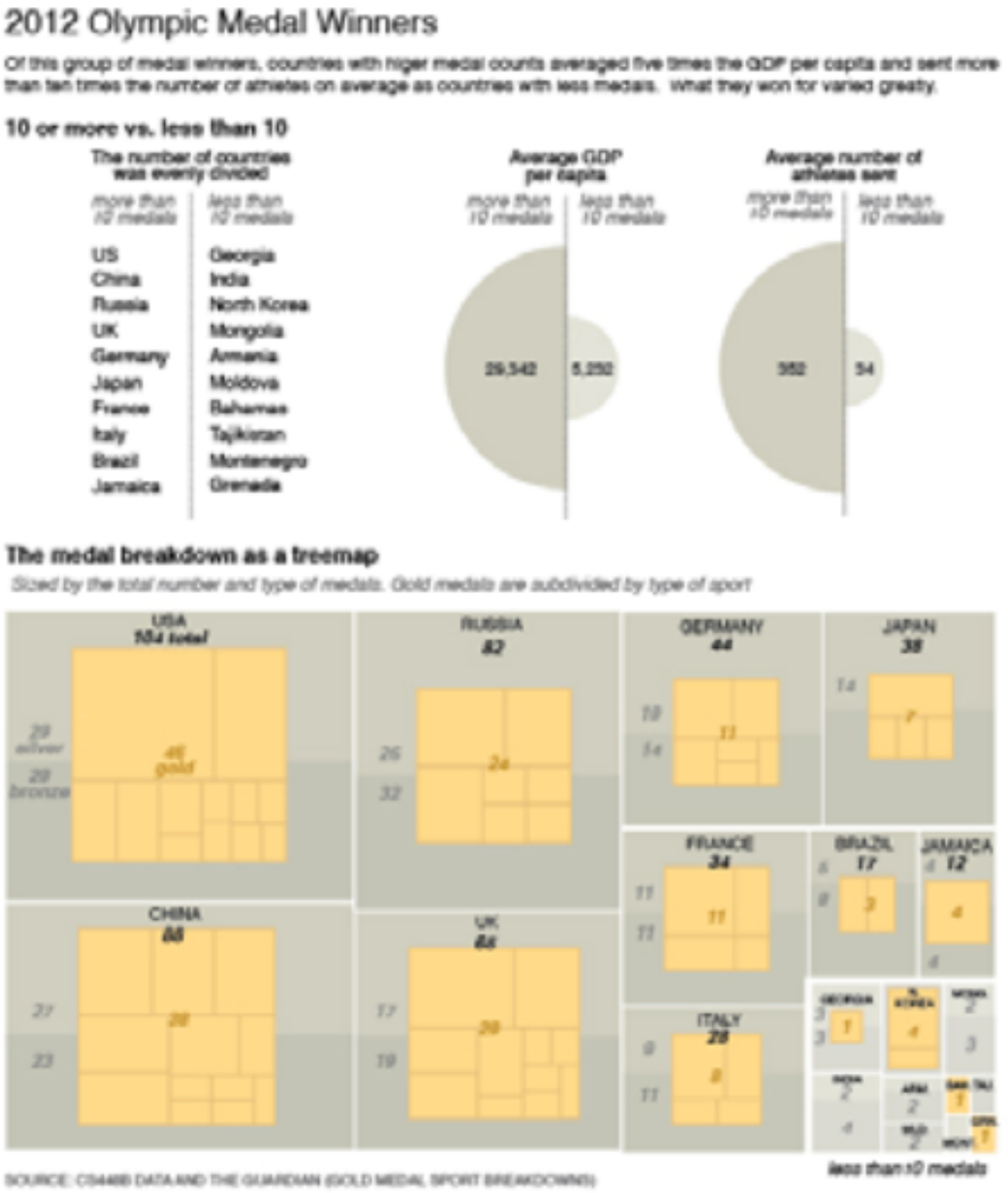
Maps


Olympic Effeciency: Medaling Rates
Olympics media coverage focuses on raw medal count, but what about olympic success rate? If success is defined as winning a medal, the teams that win the highest percentage of medals they competed for could be said to have the overall highest-quality olympic team. The map below colors countries according to their medaling rate, and the graph presents same data in two dimension along with another dimension -- data points are sized according to the ratio of medals to athletes on the team.

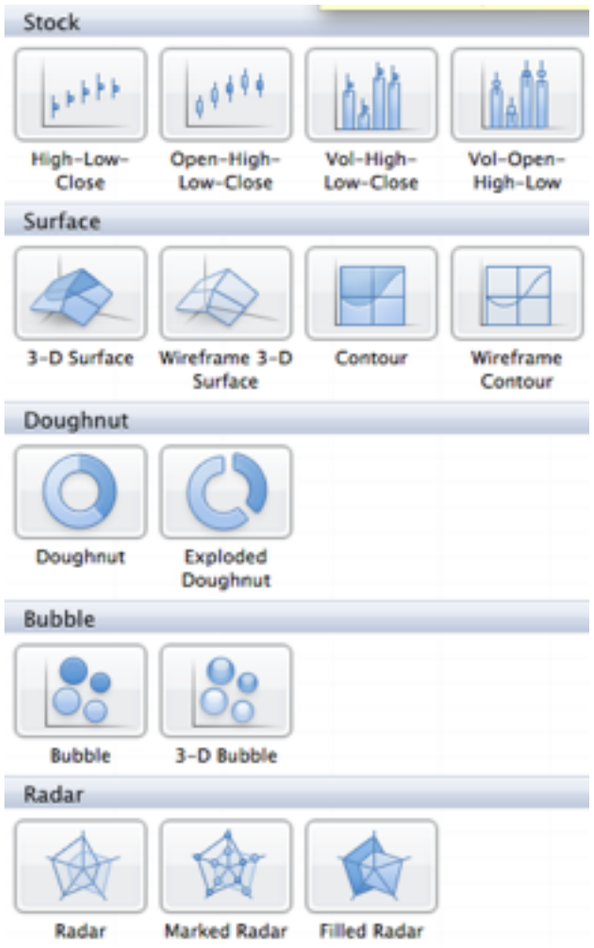
Other

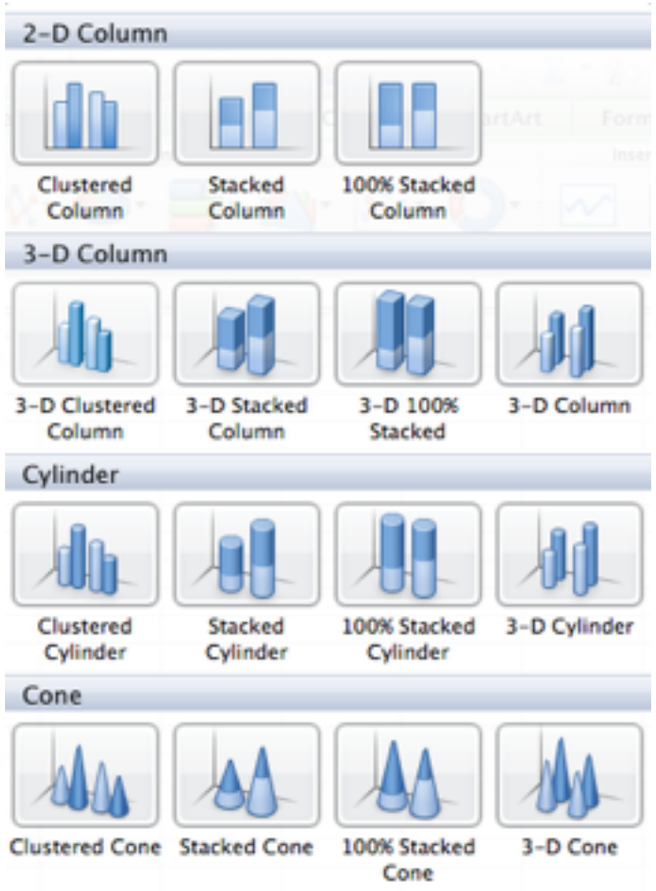

How did the Females do?
Representation and Success of Females vs. Males at the 2012 London Olympics
United States
China
Russia
United Kingdom
Germany
Japan
France
Italy
Brazil
Jamaica
Georgia
North Korea
India
Mongolia
Armenia
Moldova
Grenada
Montenegro
Tajikistan
Bahamas
KEY
Scale:
50% mark:
% female athletes of total athletes from country:
% male athletes of total athletes from country:
% female athletes from country who medaled:
% male athletes from country who medaled:
% of males and females average (ie. both 50%):
Radius of circle (measuring from center)
0%
50%
100%
Lighter rings = representation
Darker rings = medaling
Emily Cheng - CS4438 Zoos 1

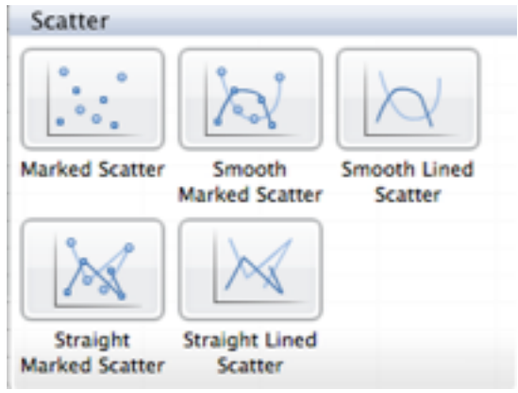
Other

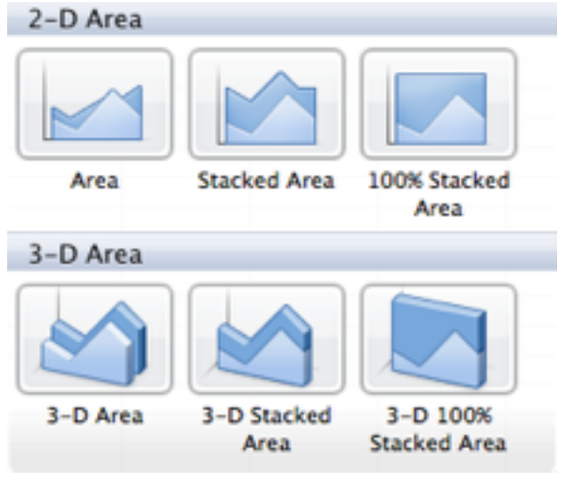

2012 Olympic Medal Winners
Of this group of medal winners, countries with higer medal counts averaged five times the GDP per capita and sent more than ten times the number of athletes on average as countries with less medals. What they won for varied greatly.
10 or more vs. less than 10
The number of countries was evenly divided
more than 10 medals
less than 10 medals
US
China
Russia
UK
Germany
Japan
France
Italy
Brazil
Jamaica
Georgia
India
North Korea
Mongolia
Armenia
Moldova
Bahamas
Tajikistan
Montenegro
Grenada
Average GDP per capita
more than 10 medals
less than 10 medals
29,542
5,252
Average number of athletes sent
more than 10 medals
less than 10 medals
552
54
The medal breakdown as a treemap
Sized by the total number and type of medals. Gold medals are subdivided by type of sport
USA
104 total
29 silver
46 gold
29 bronze
RUSSIA
82
26
24
32
GERMANY
44
19
11
14
JAPAN
38
14
7
CHINA
88
27
28
23
UK
65
17
29
19
FRANCE
34
11
11
11
BRAZIL
17
5
3
8
JAMAICA
12
4
4
4
ITALY
28
8
9
11
less than 10 medals
SOURCE: CS448B DATA AND THE GUARDIAN (GOLD MEDAL SPORT BREAKDOWNS)

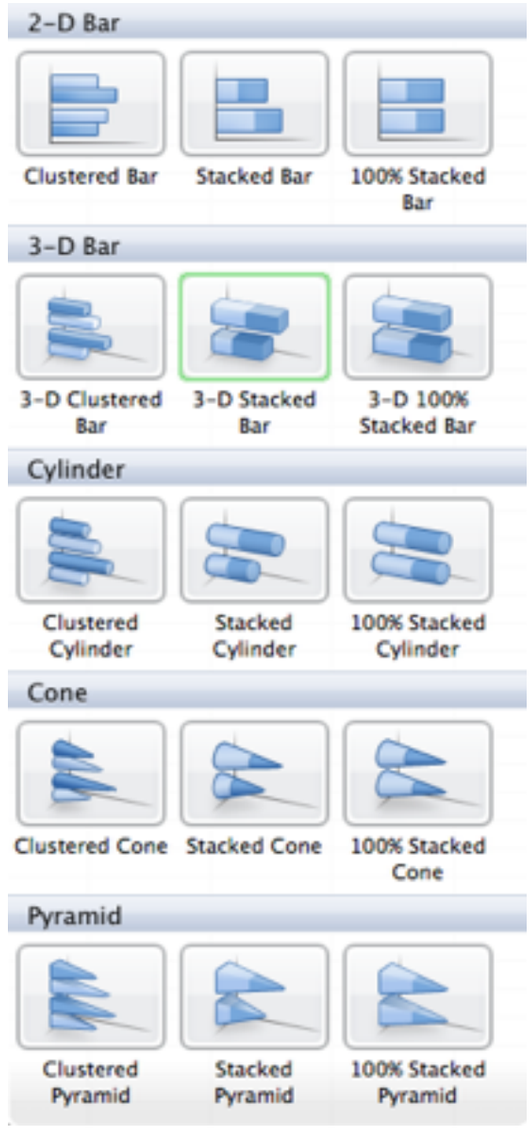
Microsoft Excel



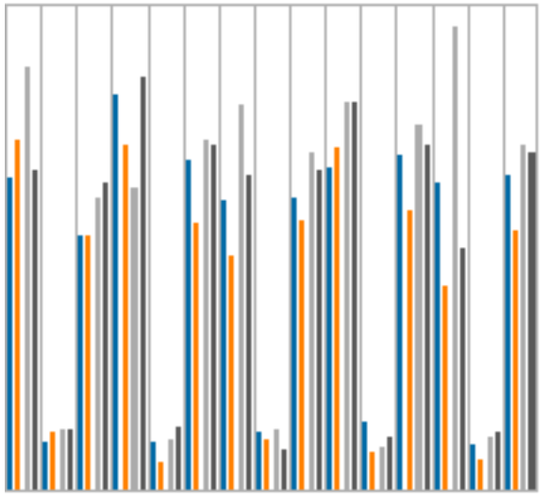




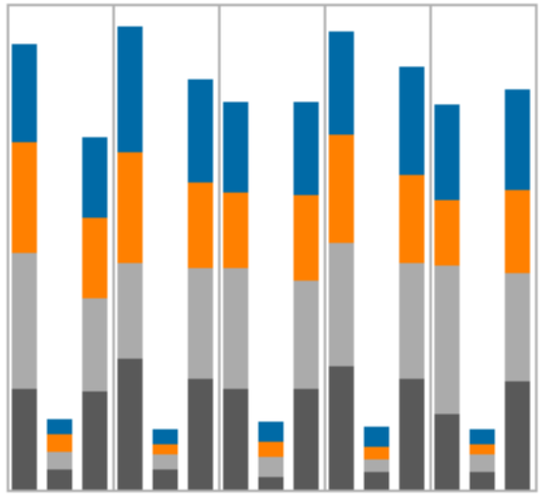




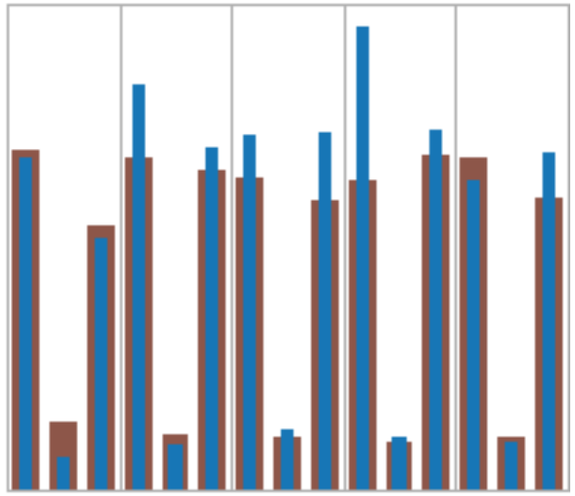
Color Bar Chart



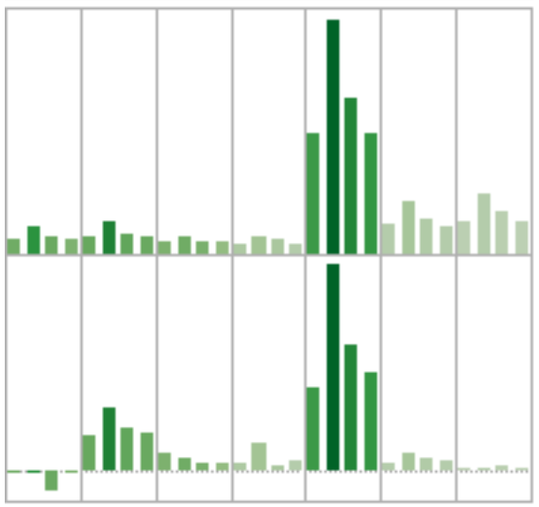
Stacked Color Bar Chart



Unstacked Color Bar Chart

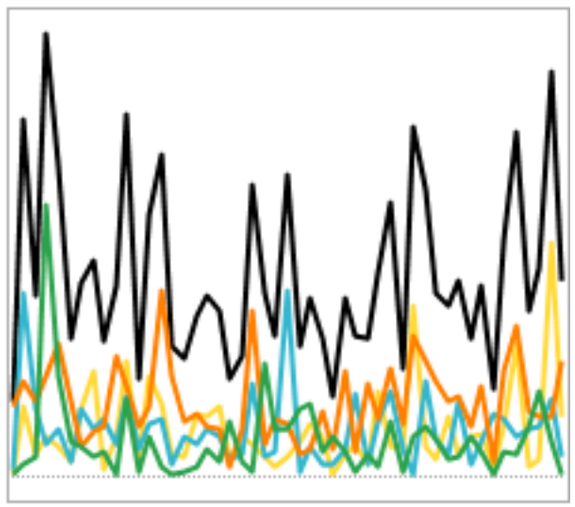


Bars III

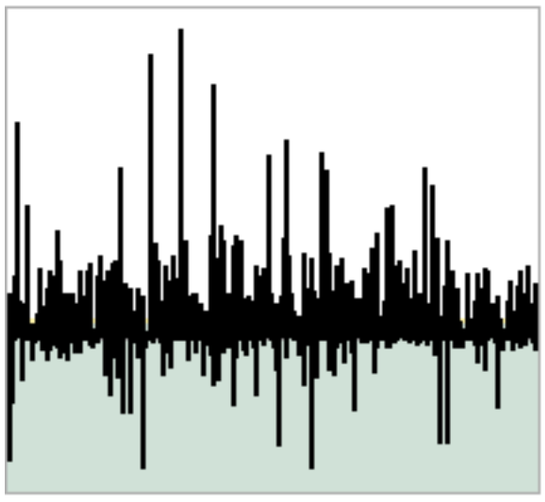


Bars and Lines III

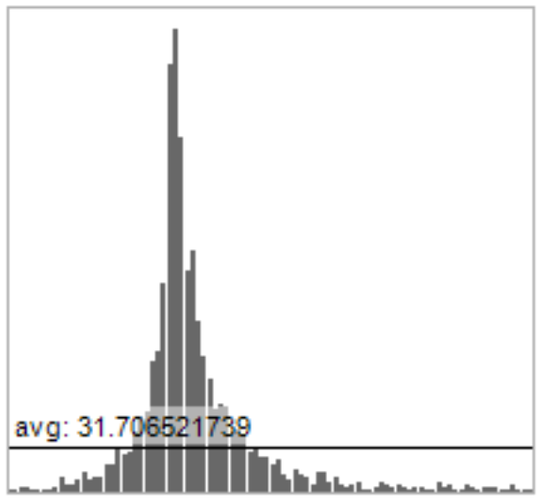
Combo Line Chart



Lines VI



Histogram



Bars II

Mass	1
New York	2
Illinois	3
Michigan	4
Idaho	5
Maryland	6
Texas	7
California	8
North Caroli..	9
New Jersey	10
Florida	11
Virginia	12
Connecticut	13

World GDP Through Time

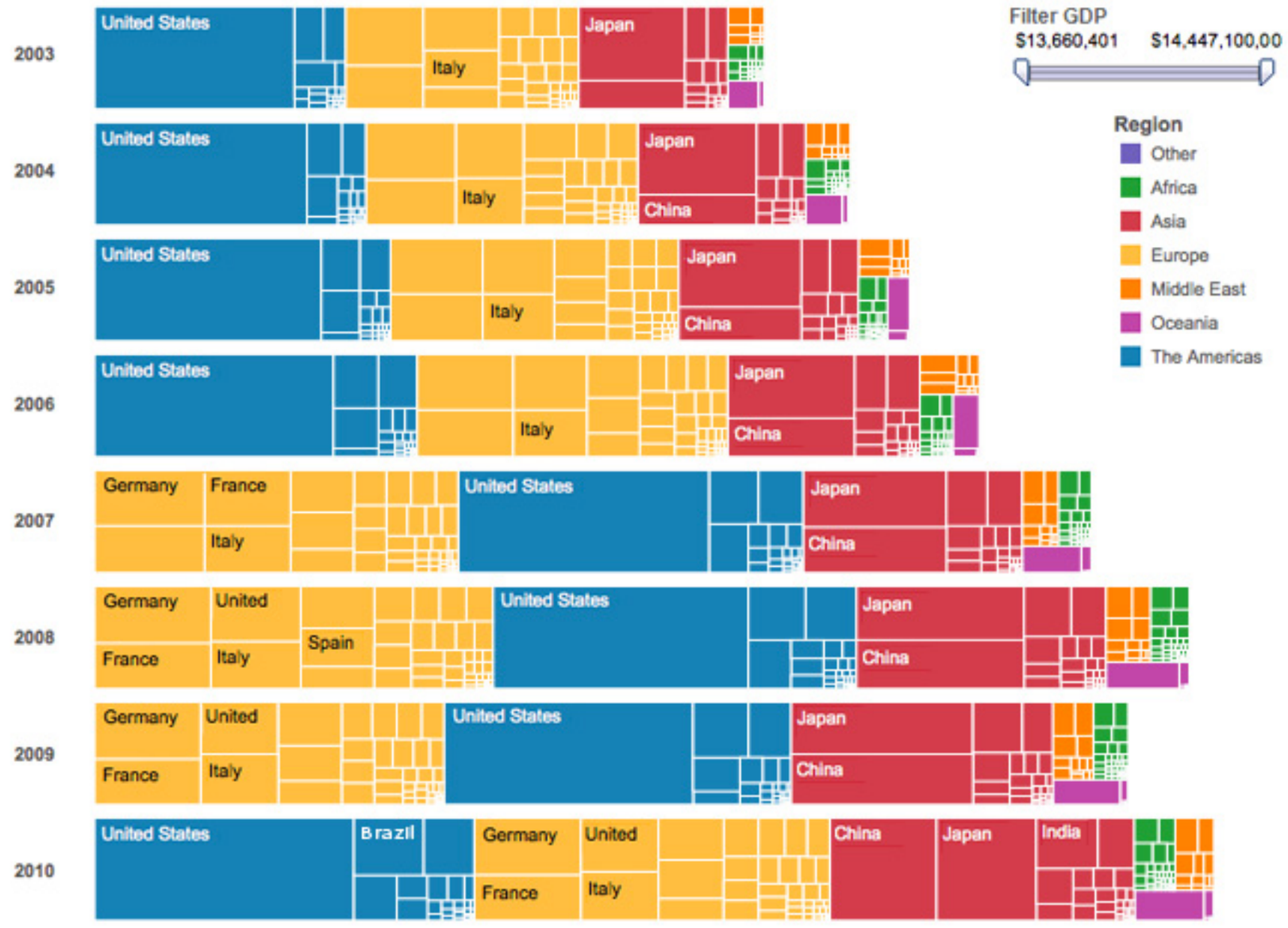
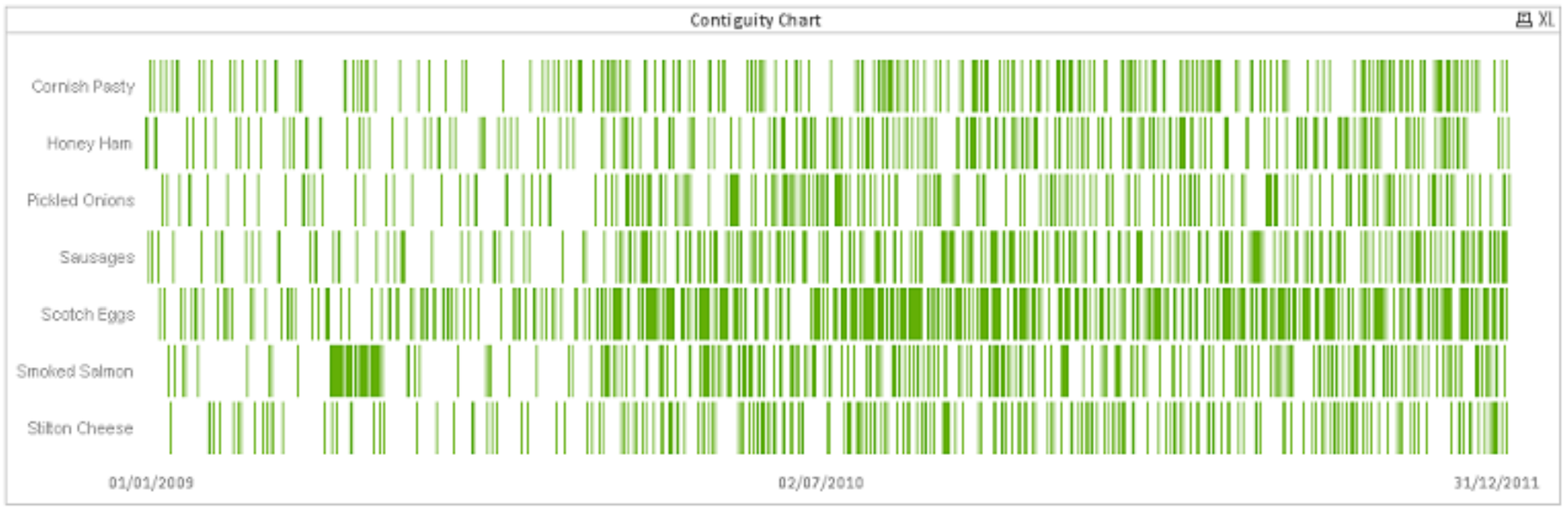


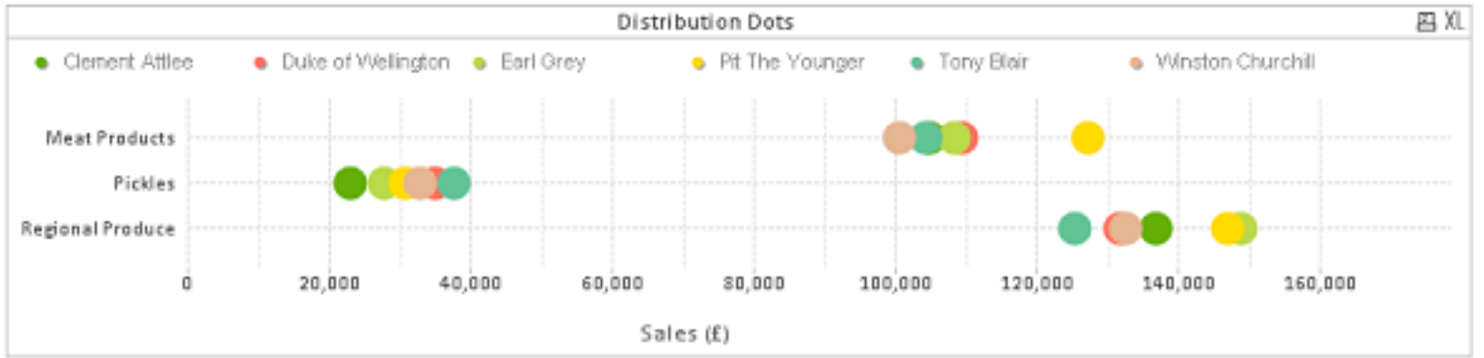
Tableau Contiguity Chart ('De-Frag')



Selections:

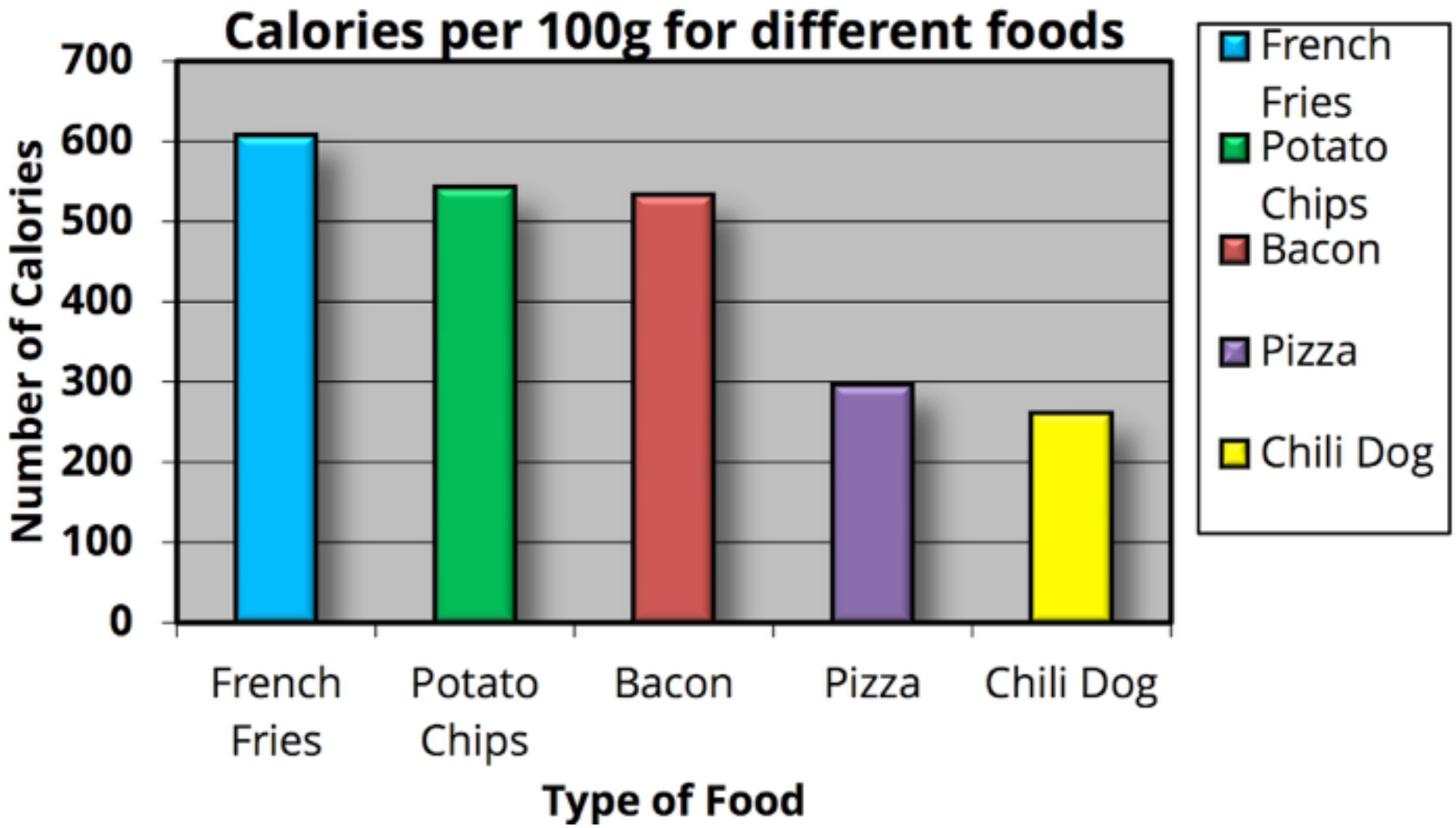
Year: 2009 | 2010 | 2011

Product:
- Cornish Pasty
- Honey Ham
- Pickled Onions
- Sausages
- Scotch Eggs
- Smoked Salmon
- Stilton Cheese

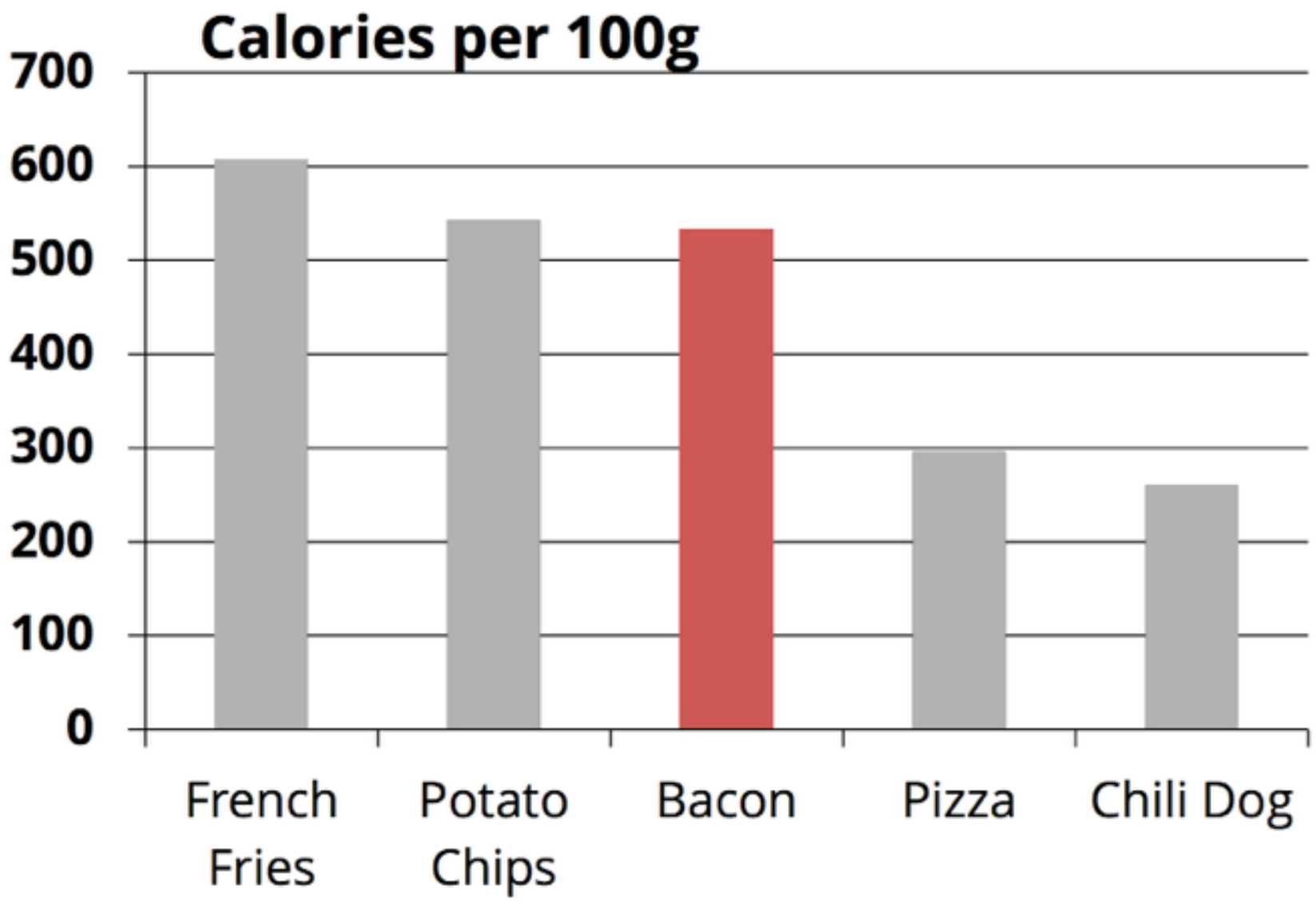


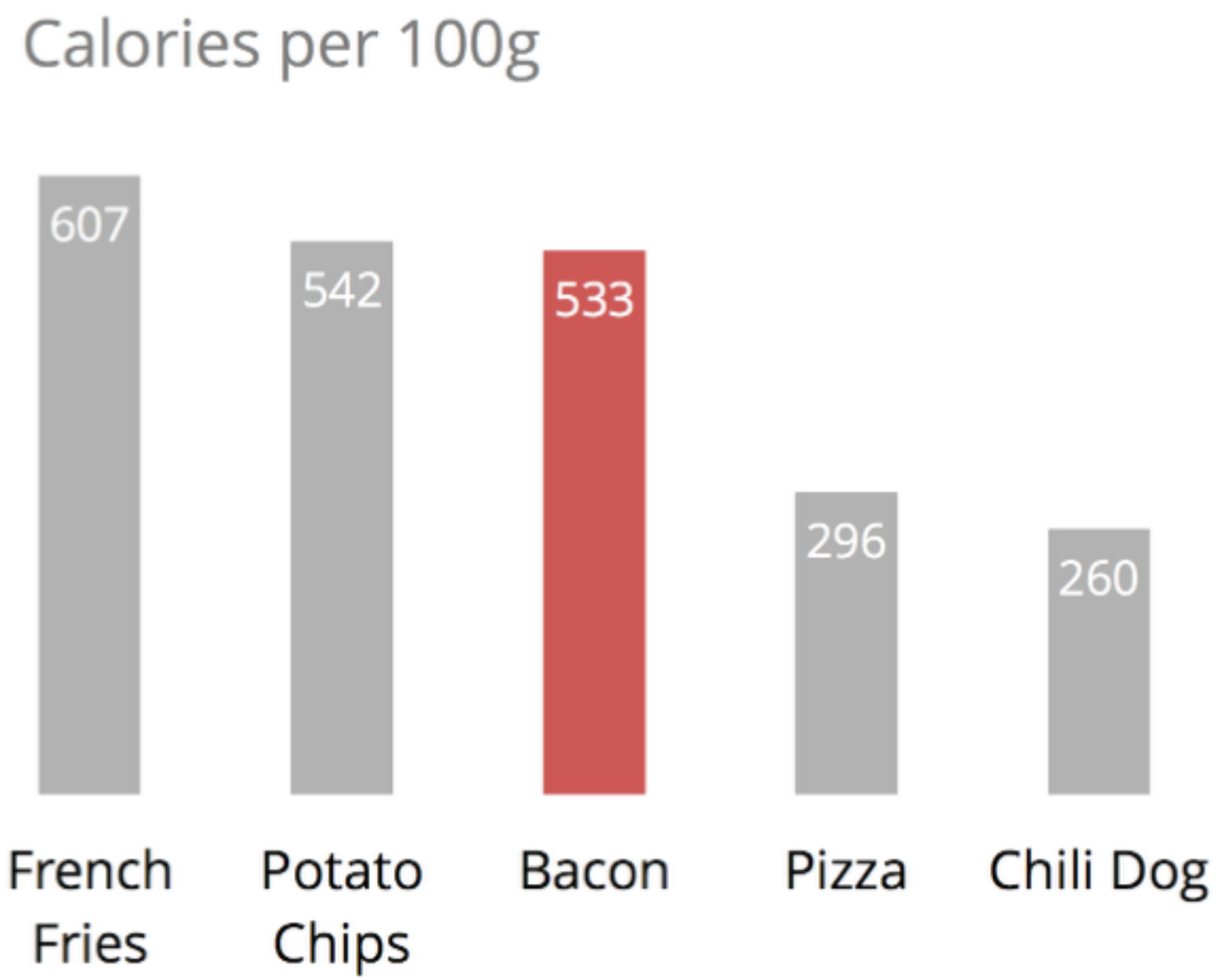

Date
Value
40
35
30
25
20
15
10
5
0
1970-05-30/
1971-02-06/
1971-10-16/
1972-06-24/
1973-03-03/
1973-11-10/
1974-07-20/
1975-03-29/
1975-12-06/
1976-08-14/
1977-04-30/
1978-01-07/
1978-09-16/
1979-05-26/
1980-02-02/
1980-10-11/
1981-06-20/
1982-02-27/
1982-11-06/
1983-07-16/
1984-03-24/
1984-12-01/
1985-08-10/
1986-04-19/
1986-12-27/
1987-09-05/
1988-05-14/
1989-01-21/
1989-09-30/
1990-06-09/
1991-02-16/
1991-10-26/
1992-07-04/
1993-03-13/
1993-11-20/
1994-07-30/
1995-04-08/
1995-12-16/
1996-08-24/
1997-05-03/
1998-01-10/
1998-09-19/
1999-05-29/
2000-02-05/
2000-10-14/
2001-06-23/
2002-03-02/
2002-11-09/
2003-07-19/
2004-03-27/
2004-12-04/
2005-08-13/
2006-04-22/
2006-12-30/
2007-09-08/
2008-05-17/
2009-01-24/
2009-10-03/
2010-06-12/

Digression - Chart Junk



https://speakerdeck.com/cherdarchuk/remove-to-improve-the-data-ink-ratio


Calories per 100g
700
600
500
400
300
200
100
0
French Fries
Potato Chips
Bacon
Pizza
Chili Dog

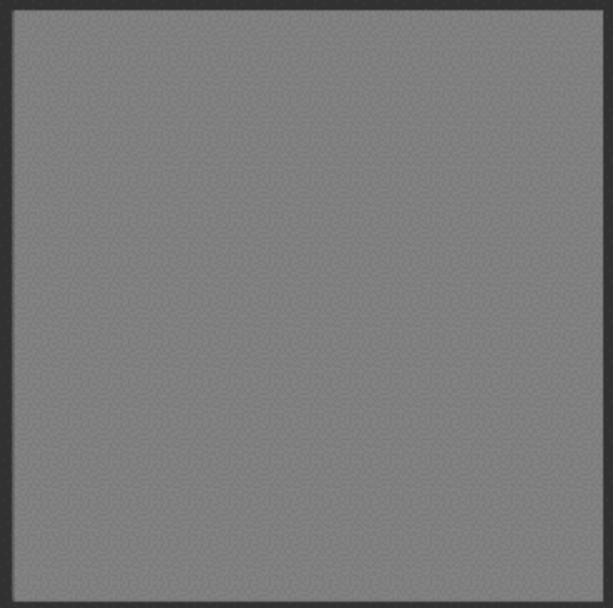

Calories per 100g
607
542
533
296
260
French Fries
Potato Chips
Bacon
Pizza
Chili Dog

Perception

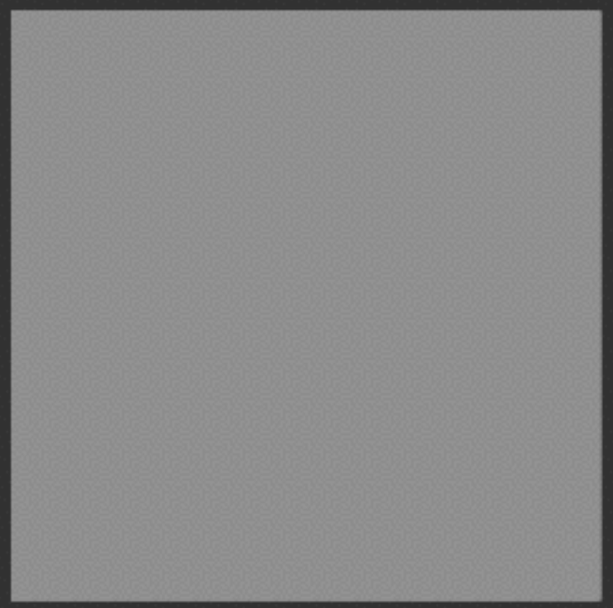
AWARENESS TEST

https://www.youtube.com/watch?v=Ahg6qcgoay4

(128, 128, 128)

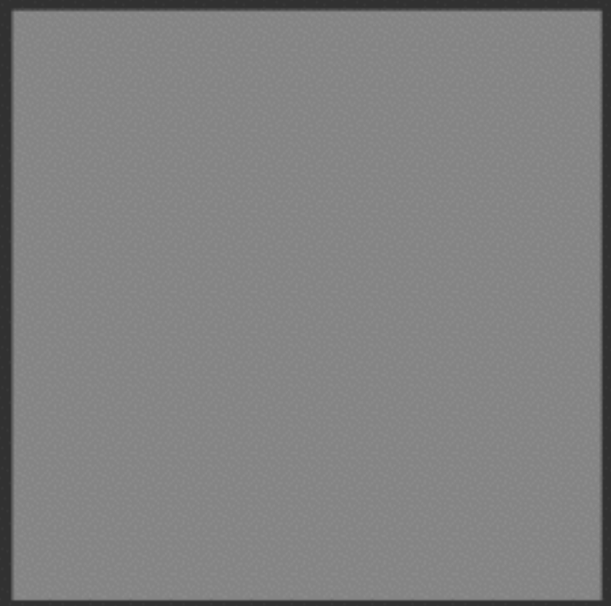


(144, 144, 144)

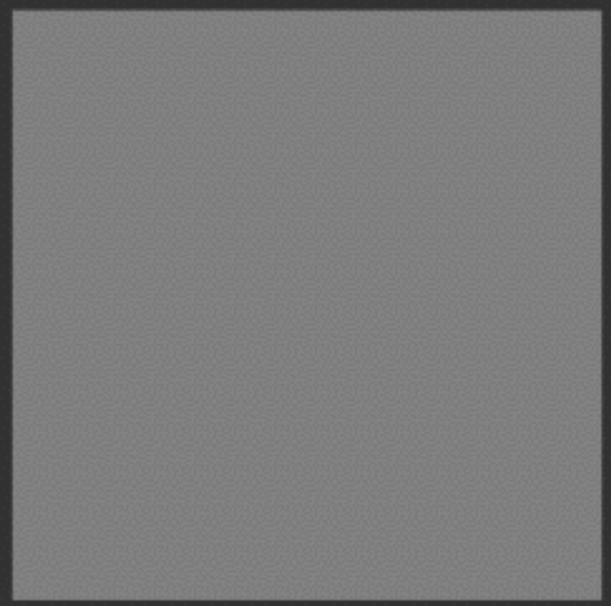


Which is brighter?

(134, 134, 134)



(128, 128, 128)



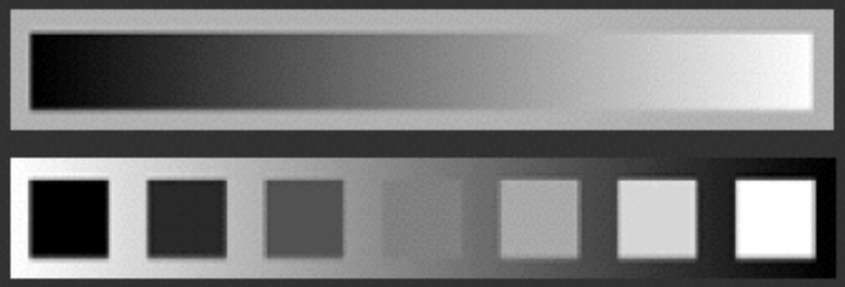
Which is brighter?

JND (Weber's Law)

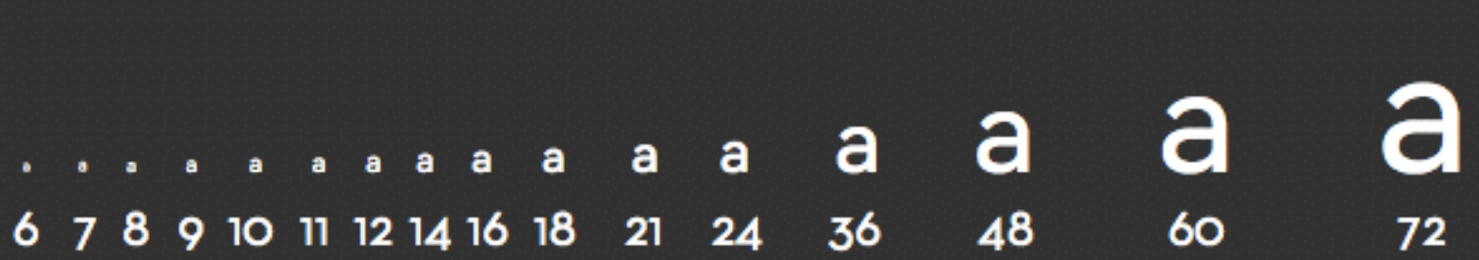
$$\Delta S = k\frac{\Delta I}{I}$$

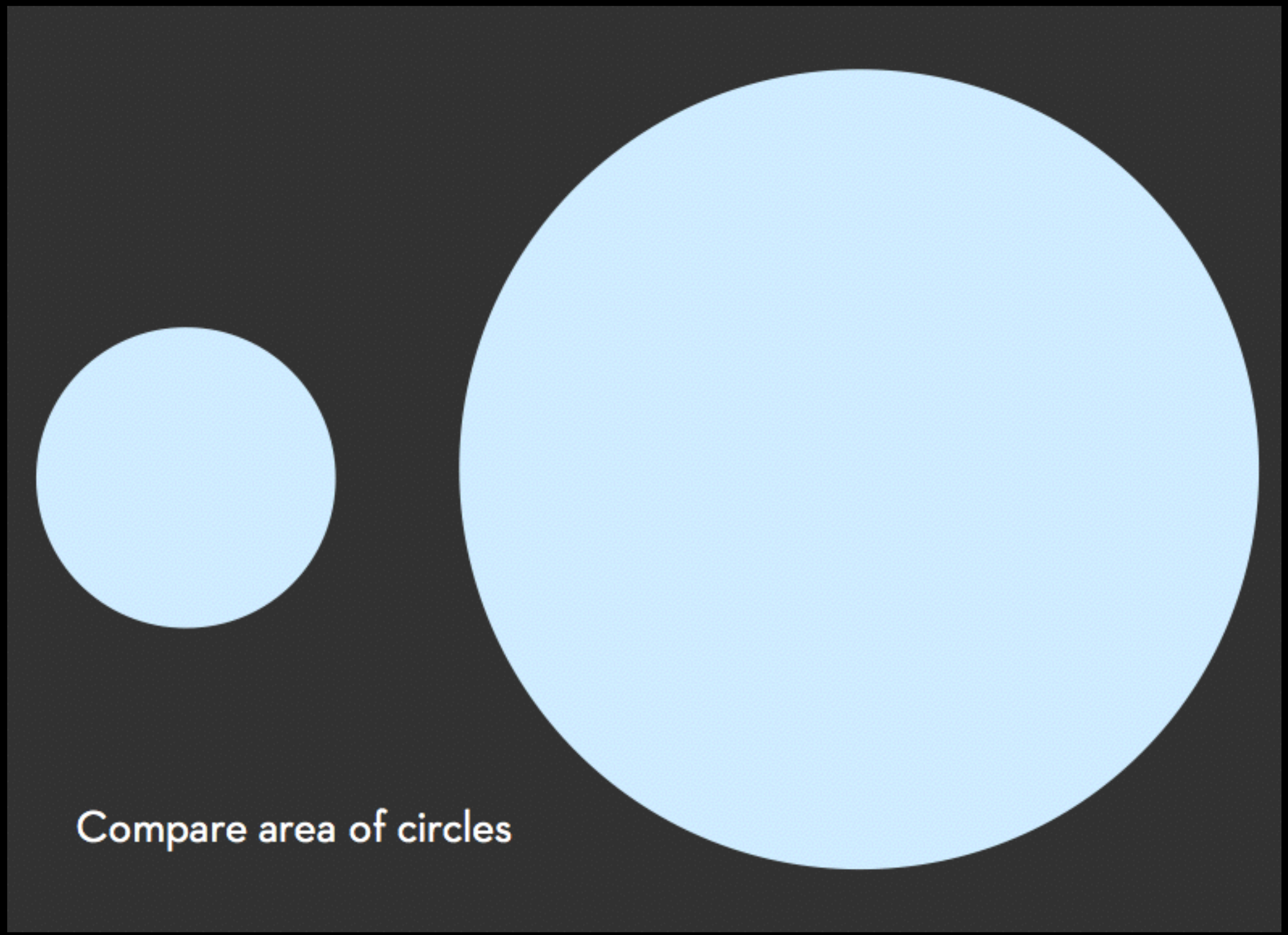
Ratios more important than magnitude

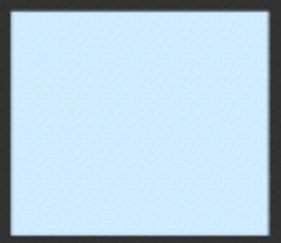
Most continuous variation in stimuli perceived in discrete steps



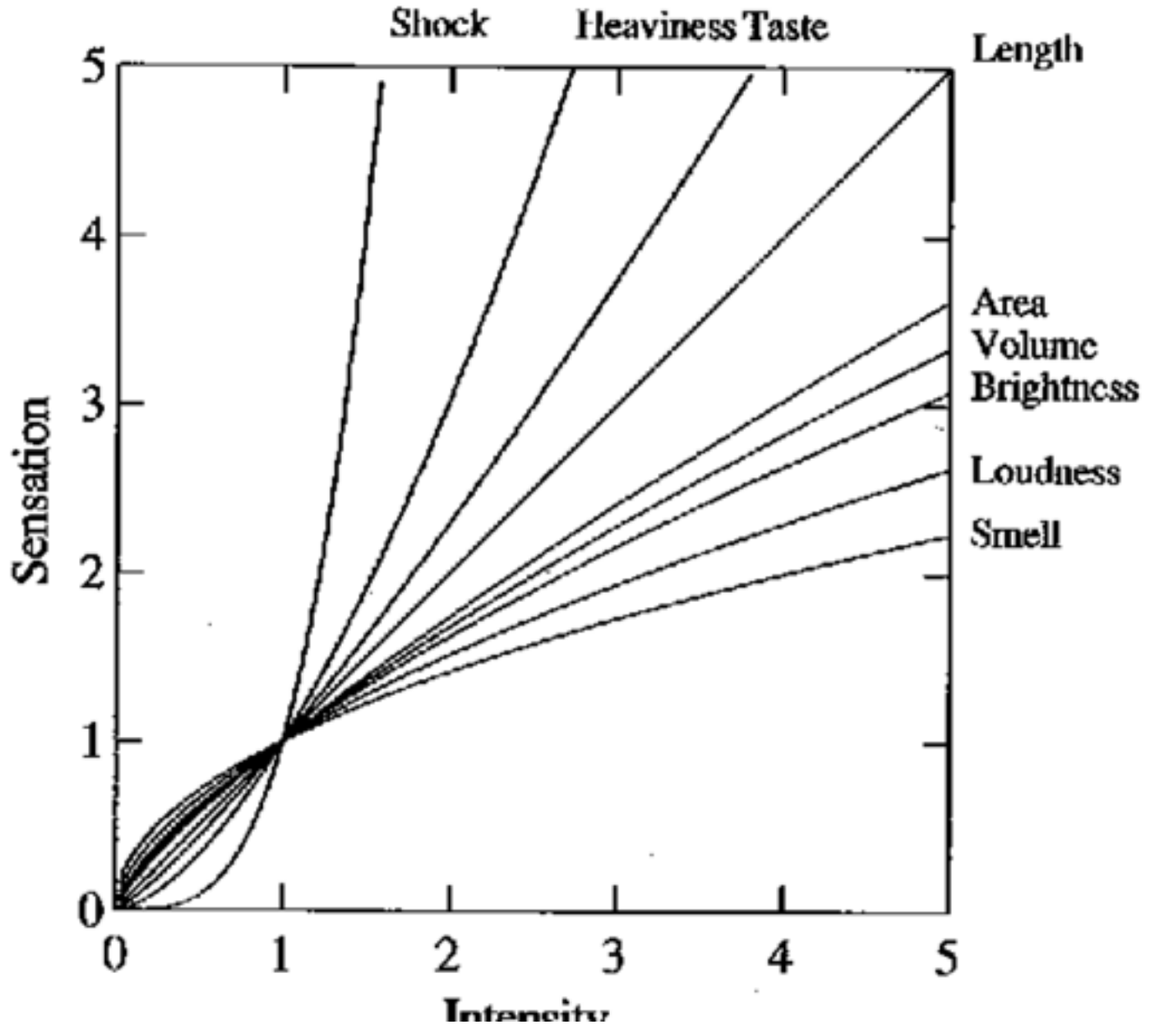
Sizes standardized in 16th century




Compare area of circles



Compare length of bars



Steven's power law

Most accurate

Least accurate

Position (common) scale

Position (non-aligned) scale

Length

Slope

Angle

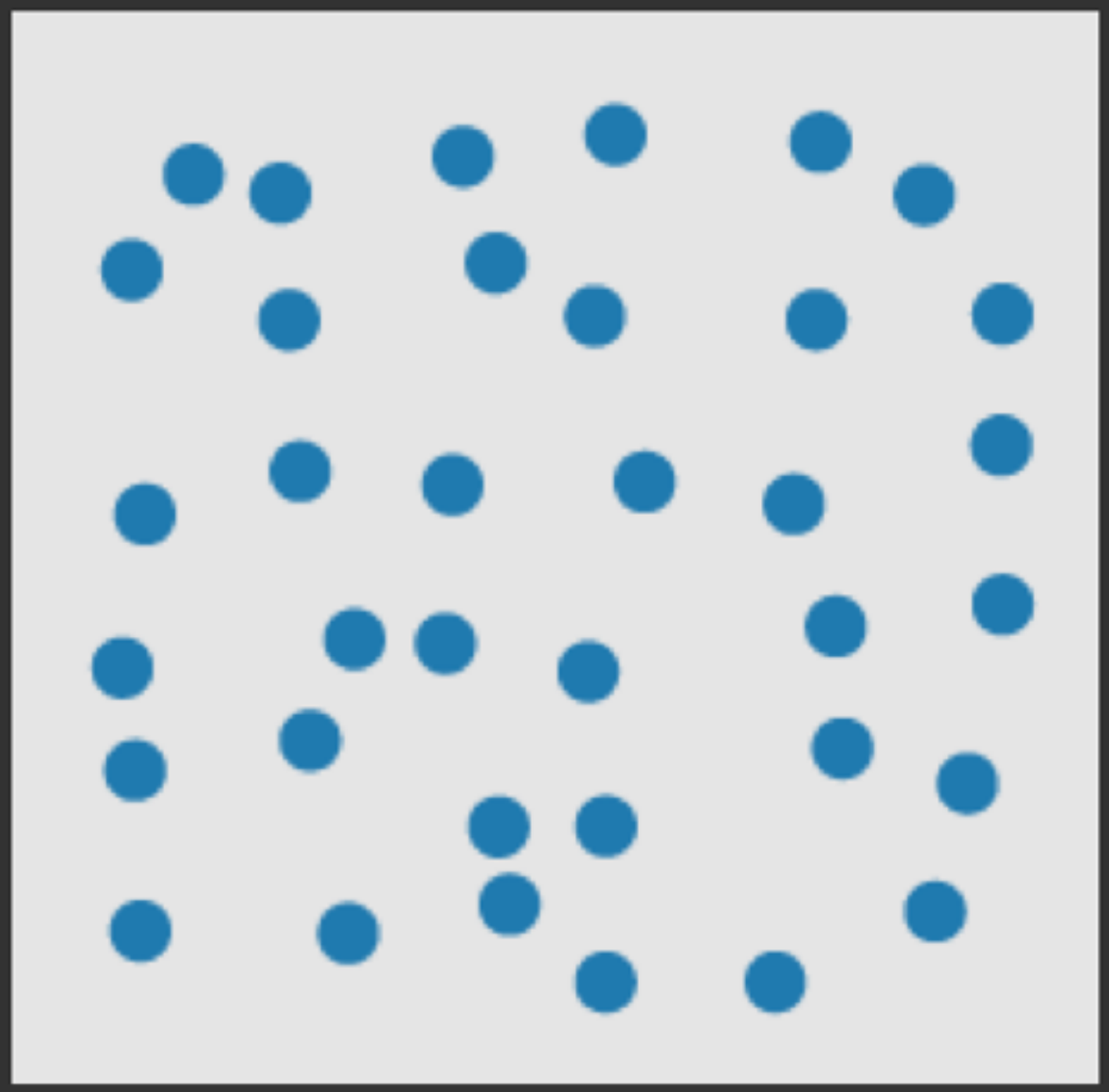
Area

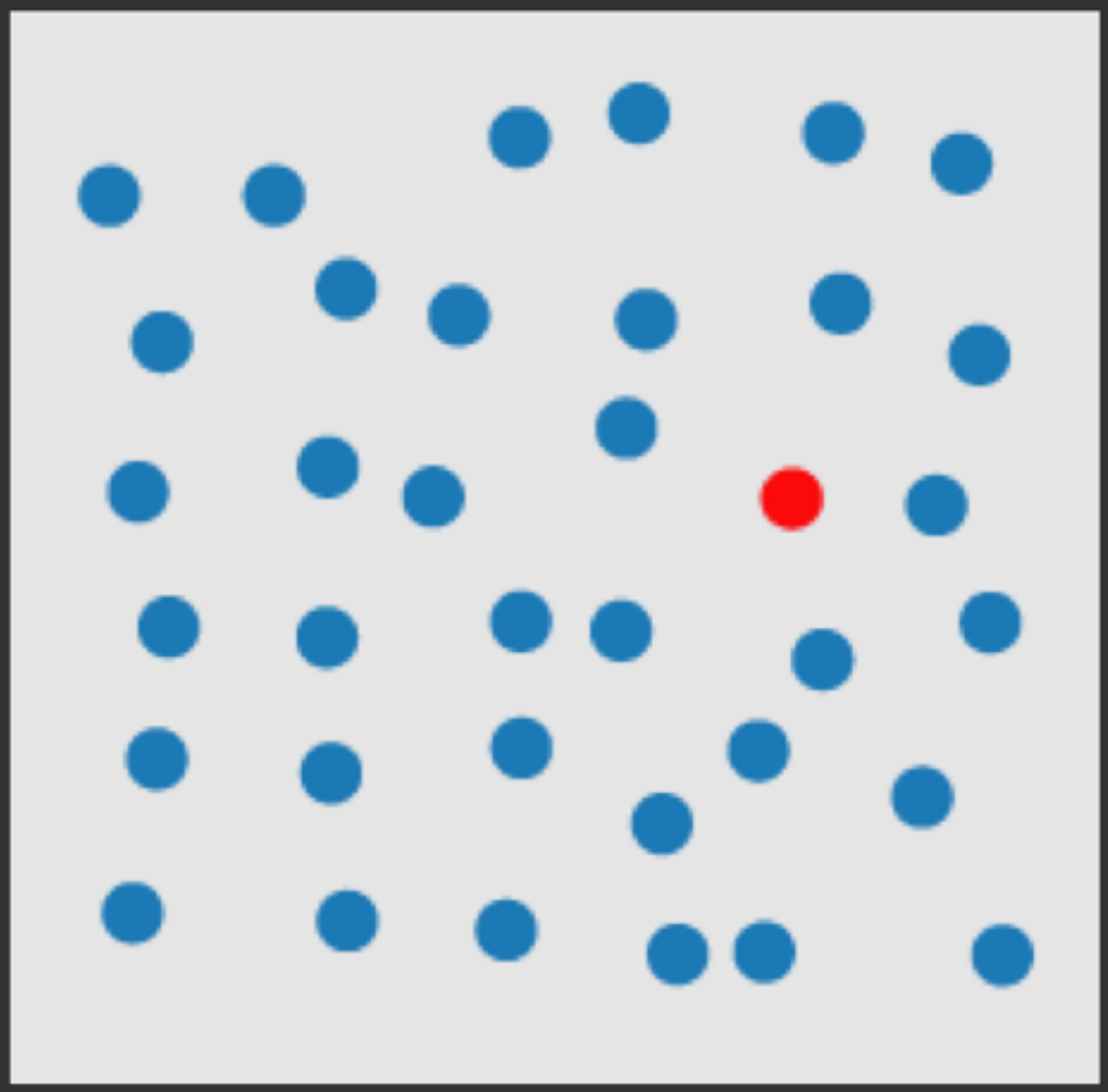
Volume

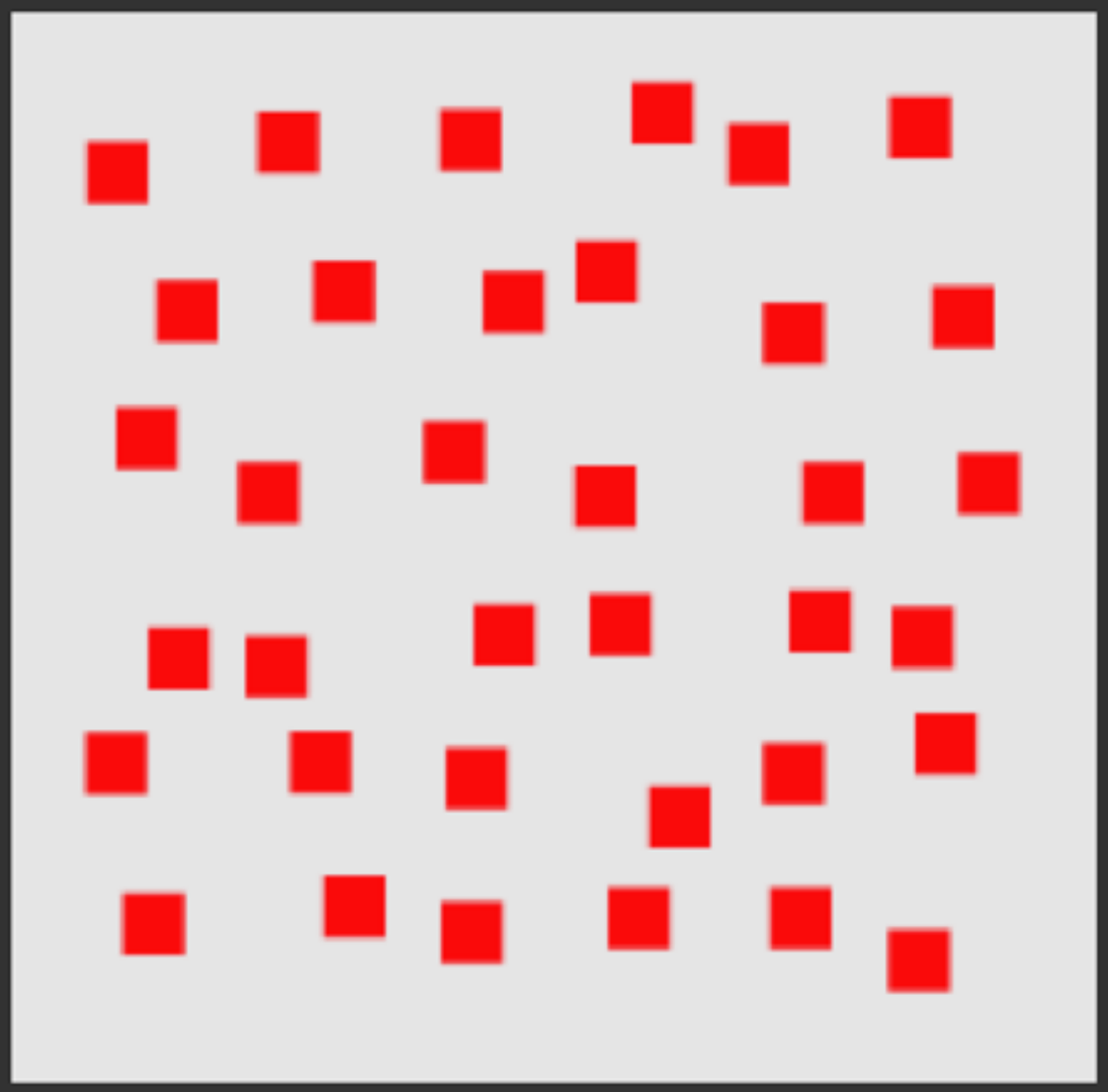
Color hue-saturation-density

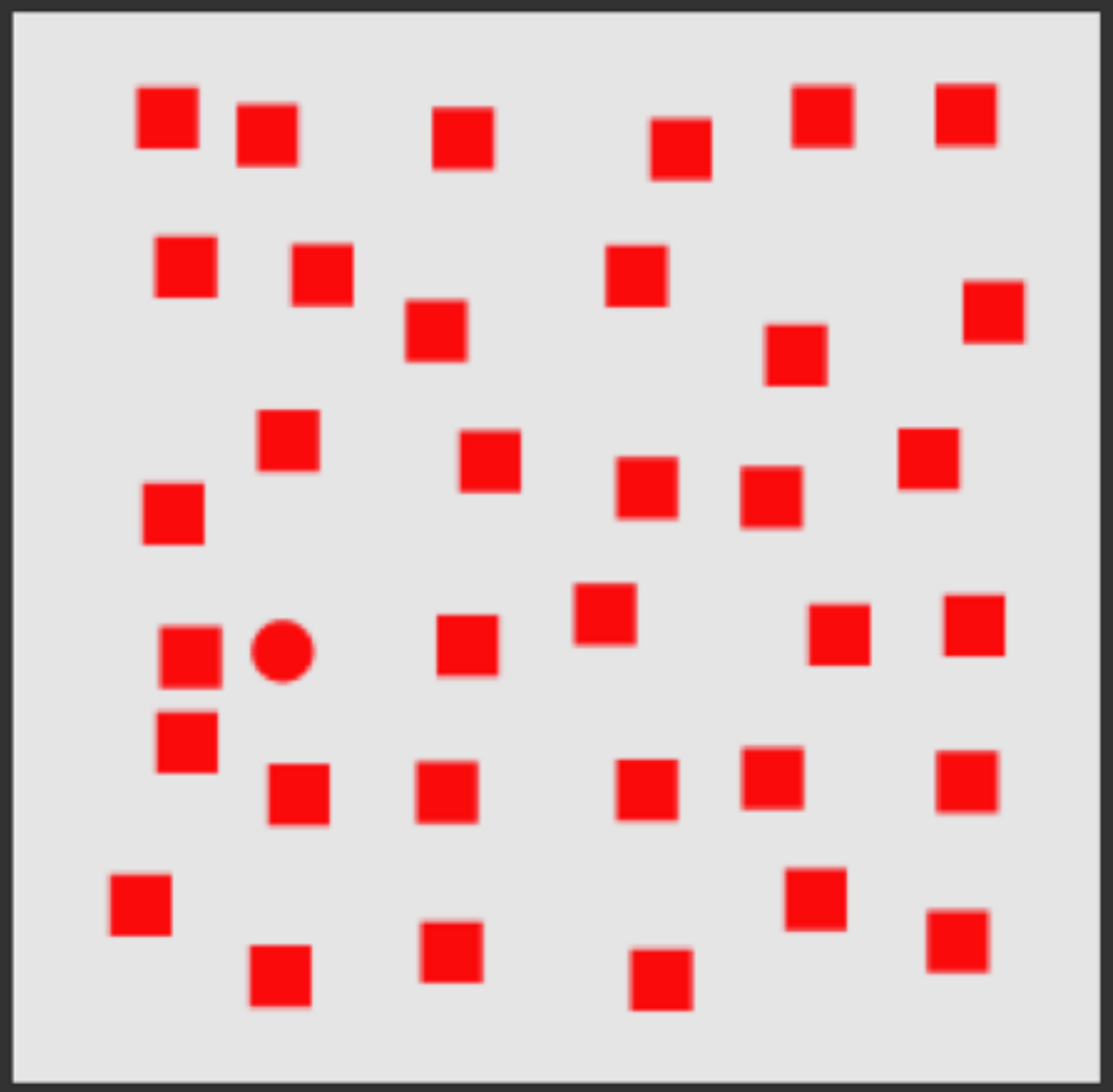
128176875613897654698450698560498282676298098584582245098564589450984509809435859091030209905959595772564675050678904567884578980982167765487636490856091294968 6

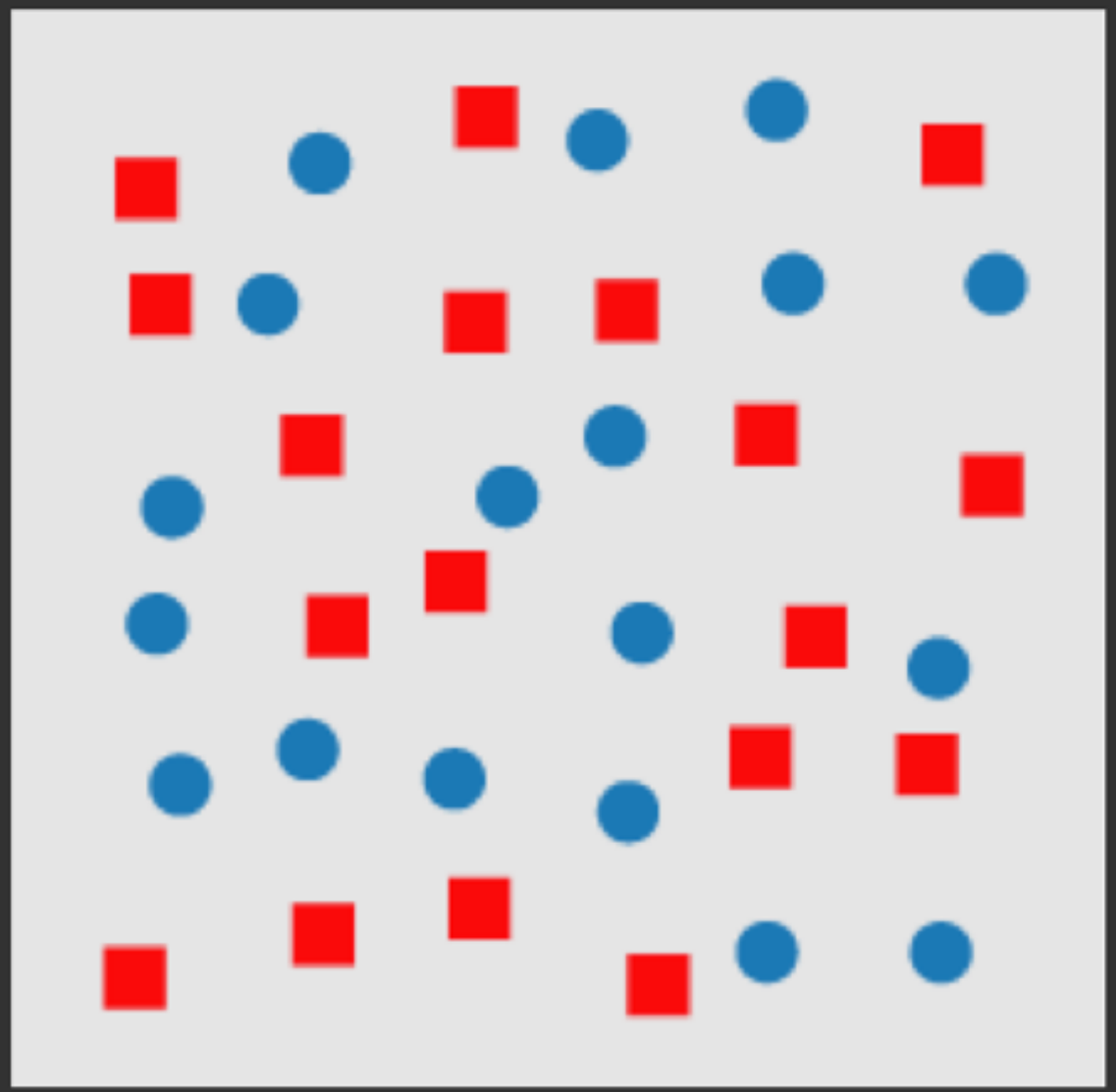
128176875613897654698450698560498282676298098584582245098564589450984509809435859091030209905959595772564675050678904567884578980982167765487636490856091294968 6

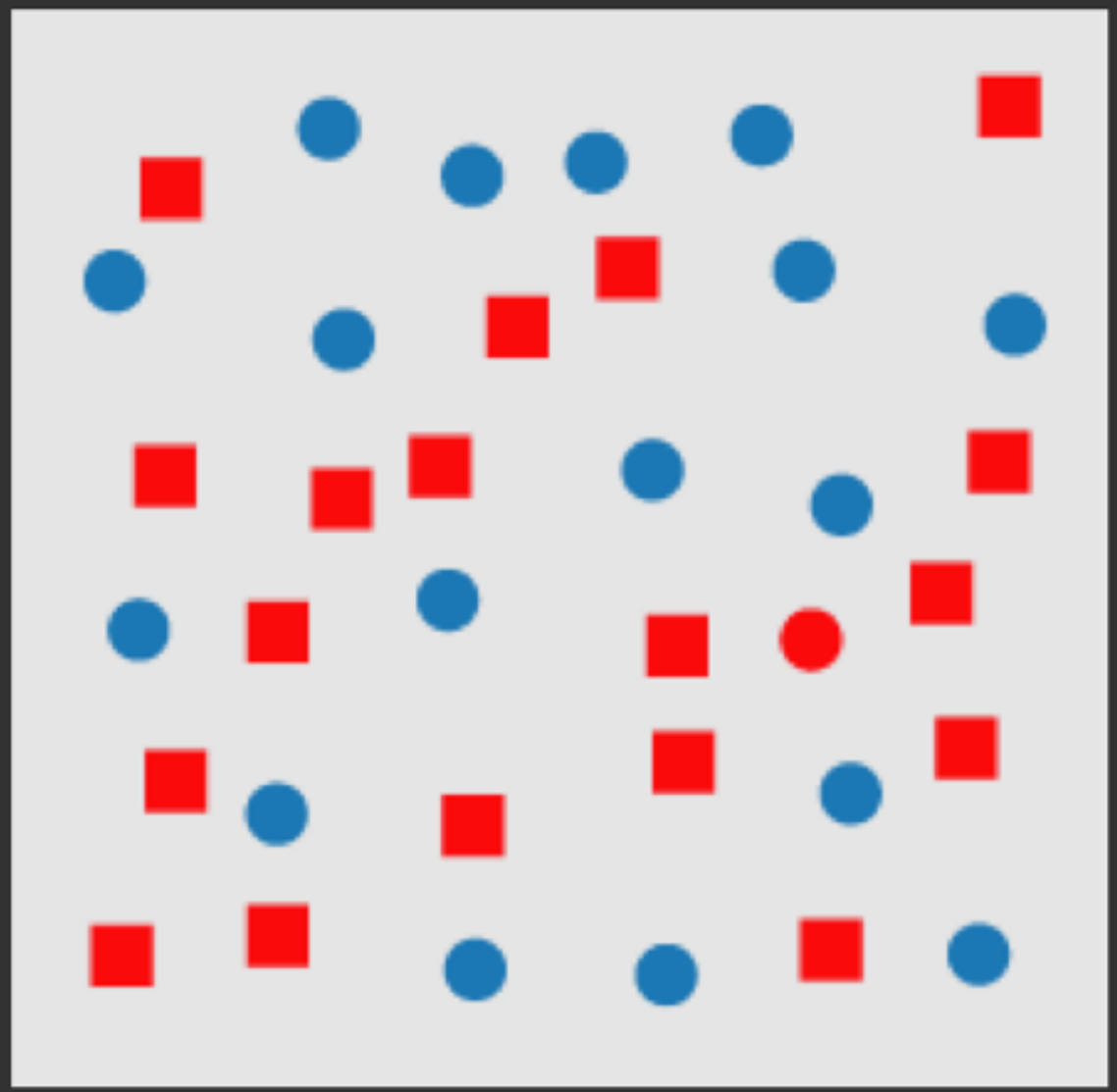


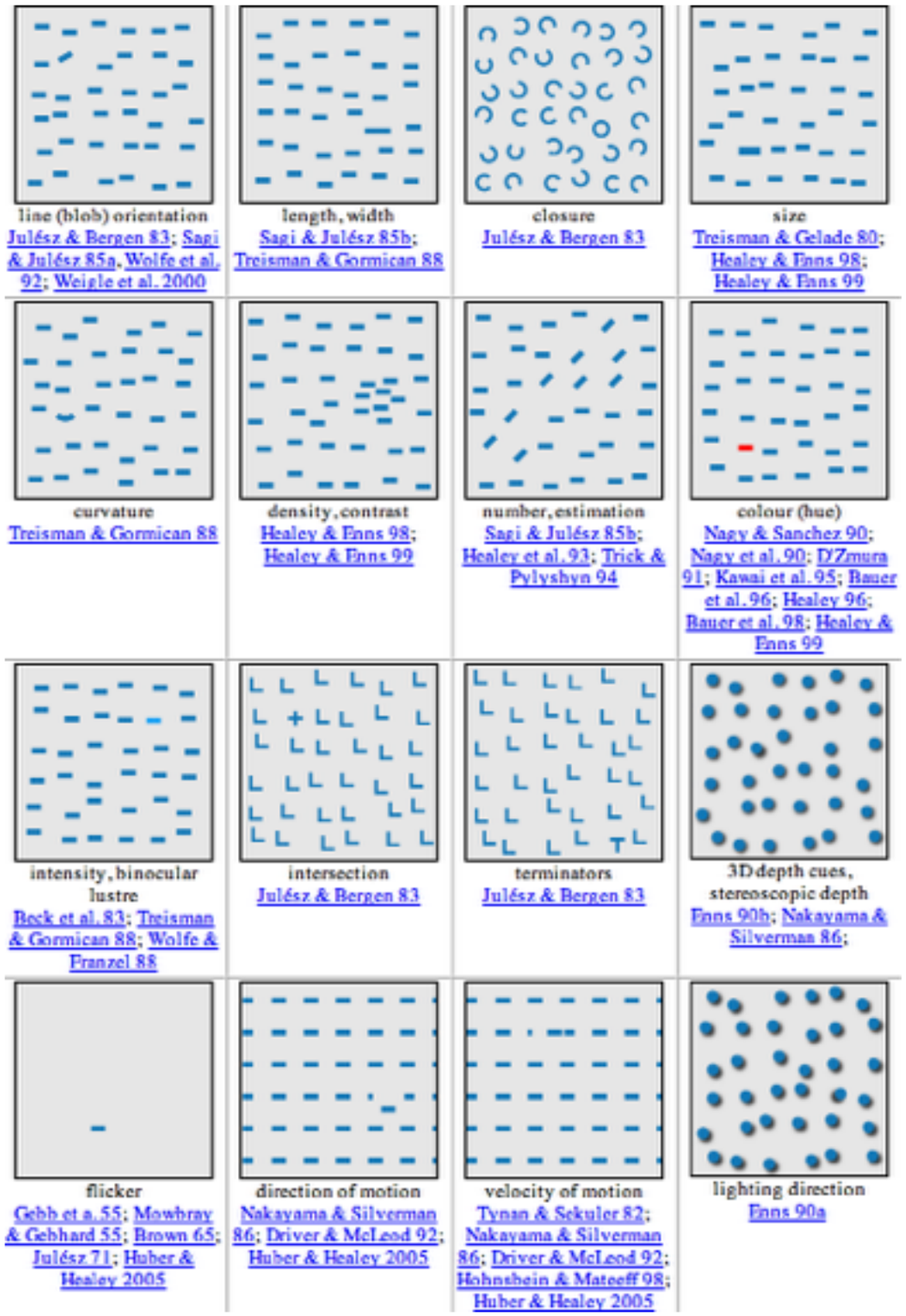




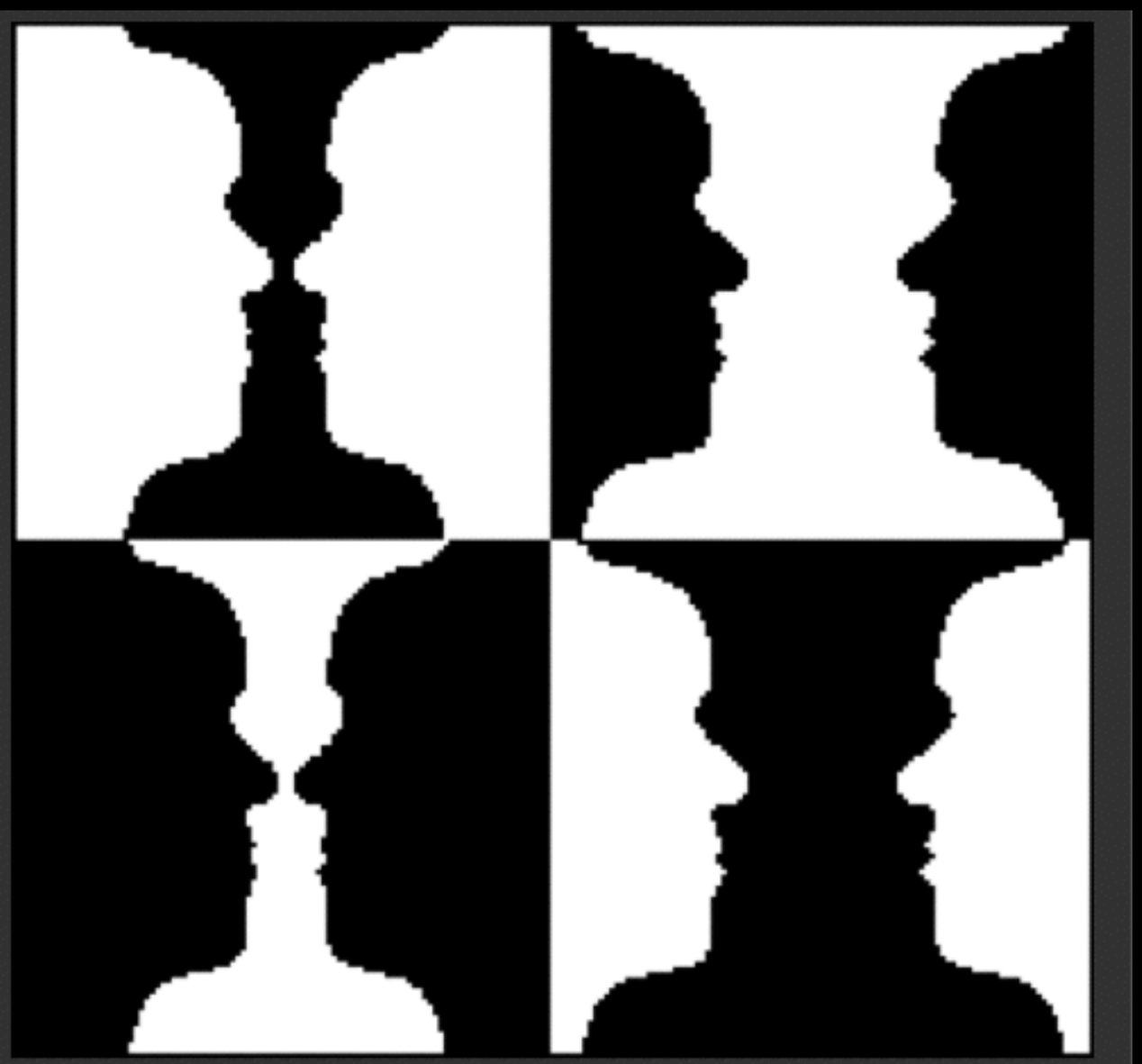


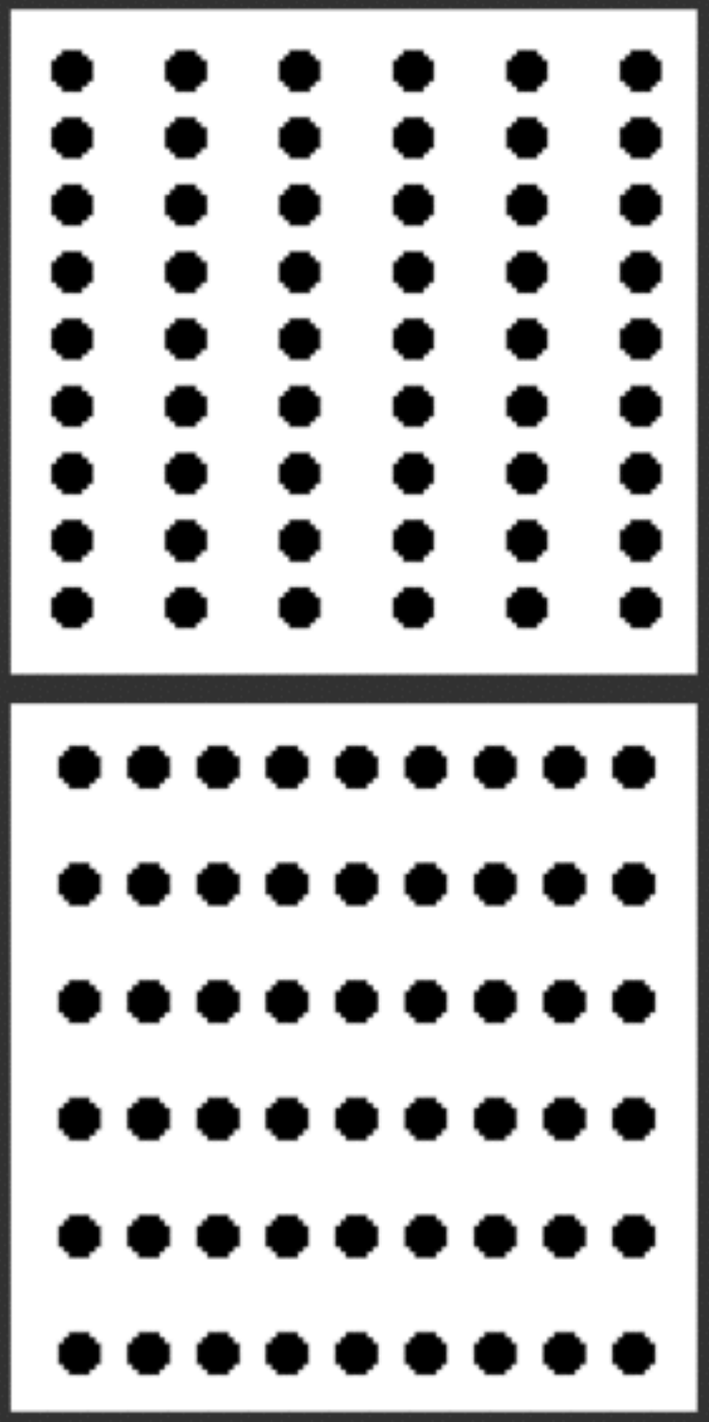


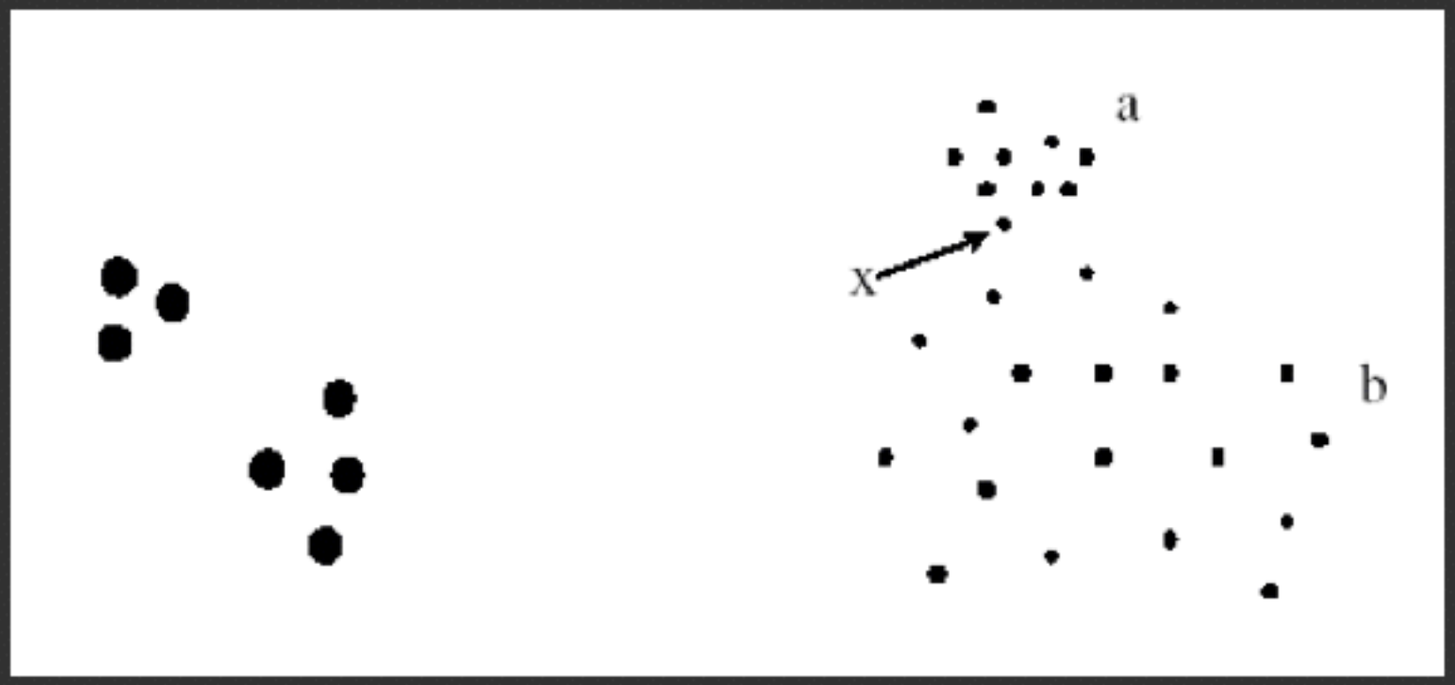




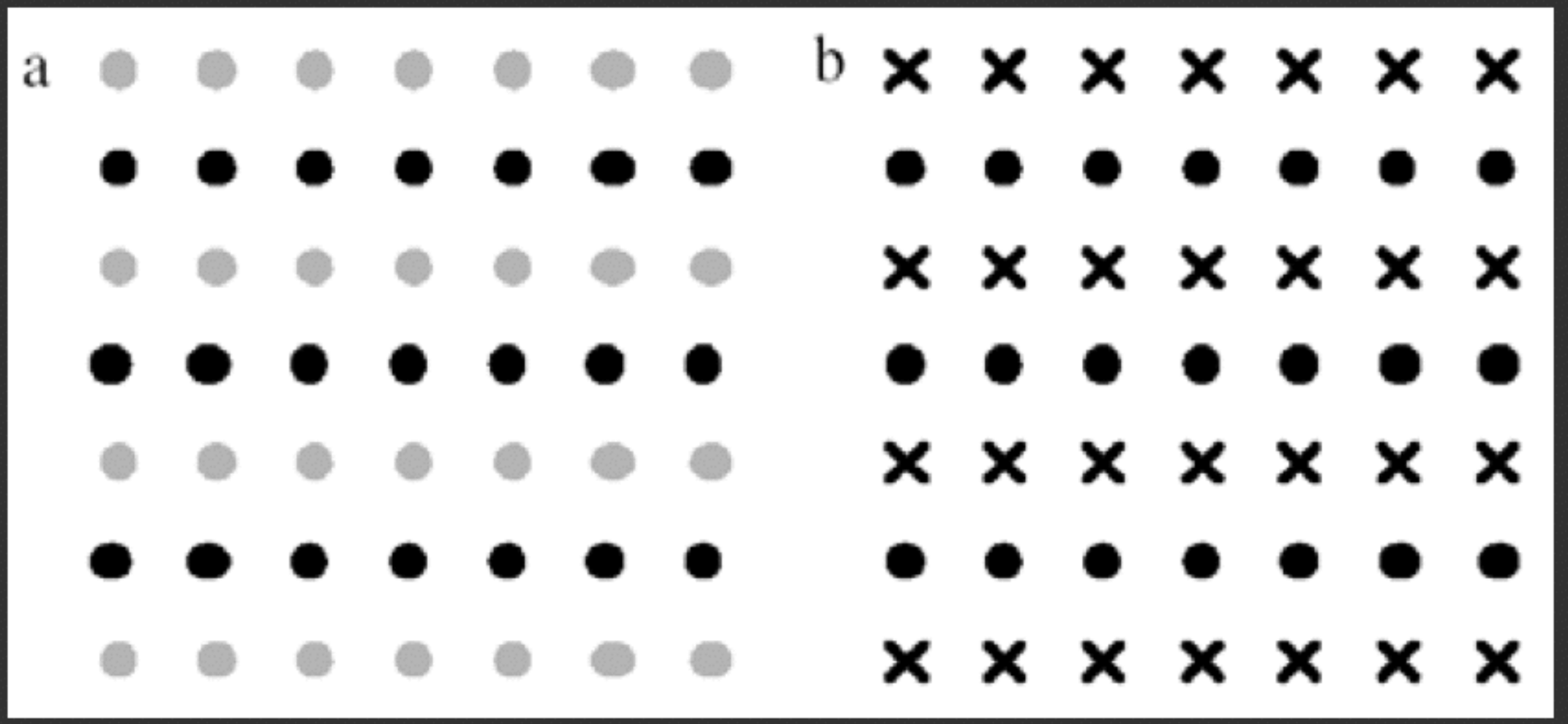
http://www.csc.ncsu.edu/faculty/healey/PP/index.html

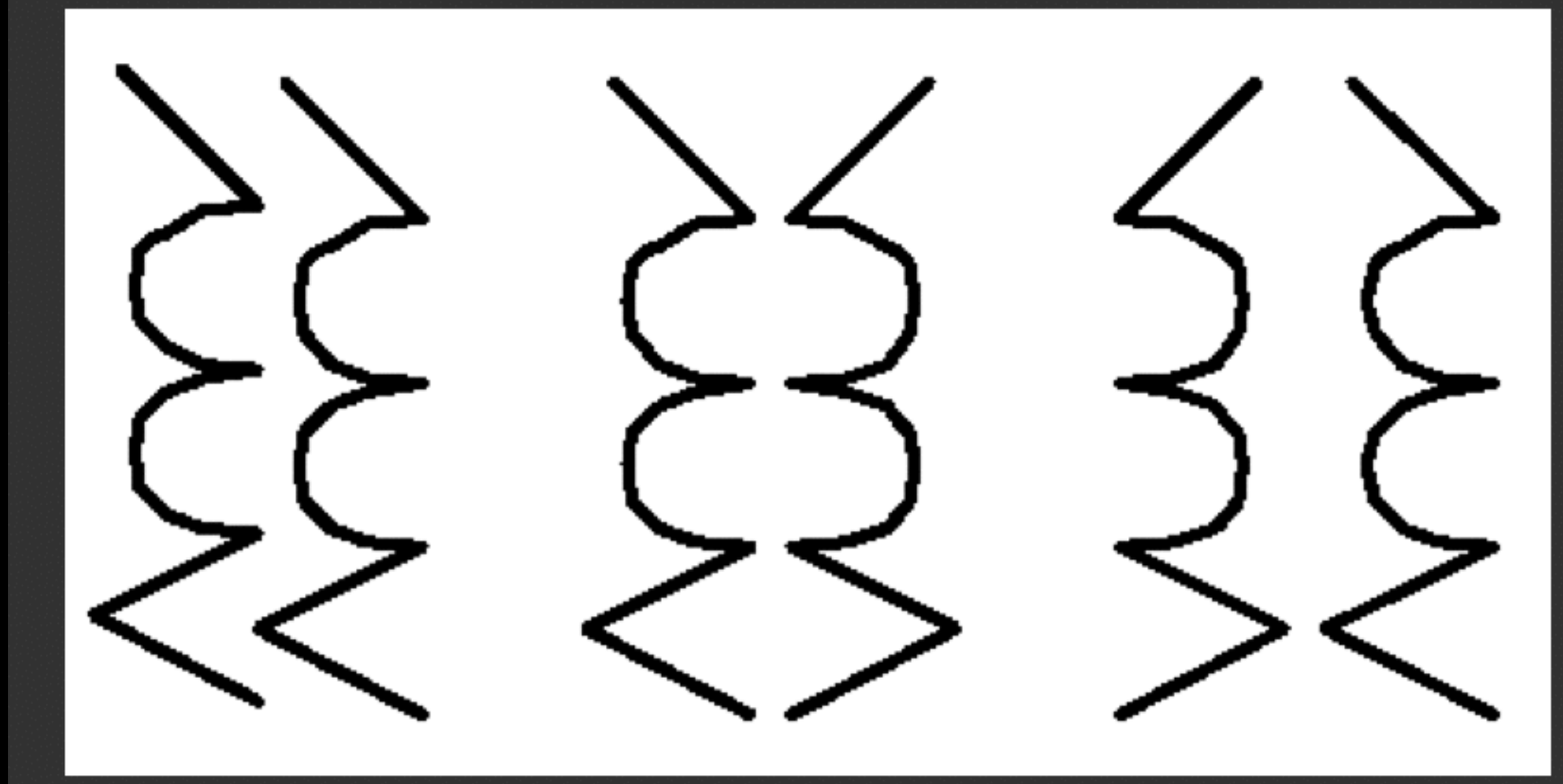


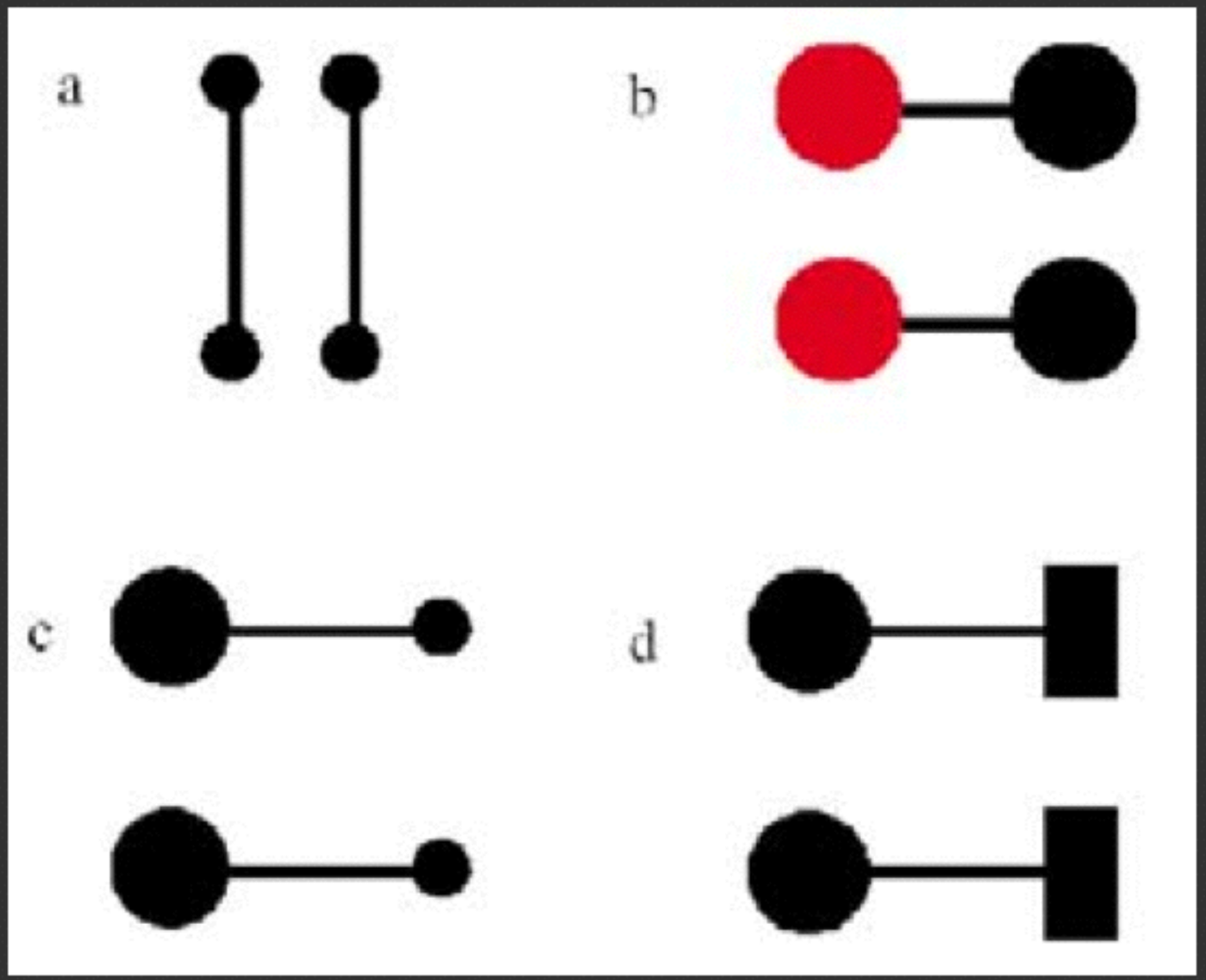


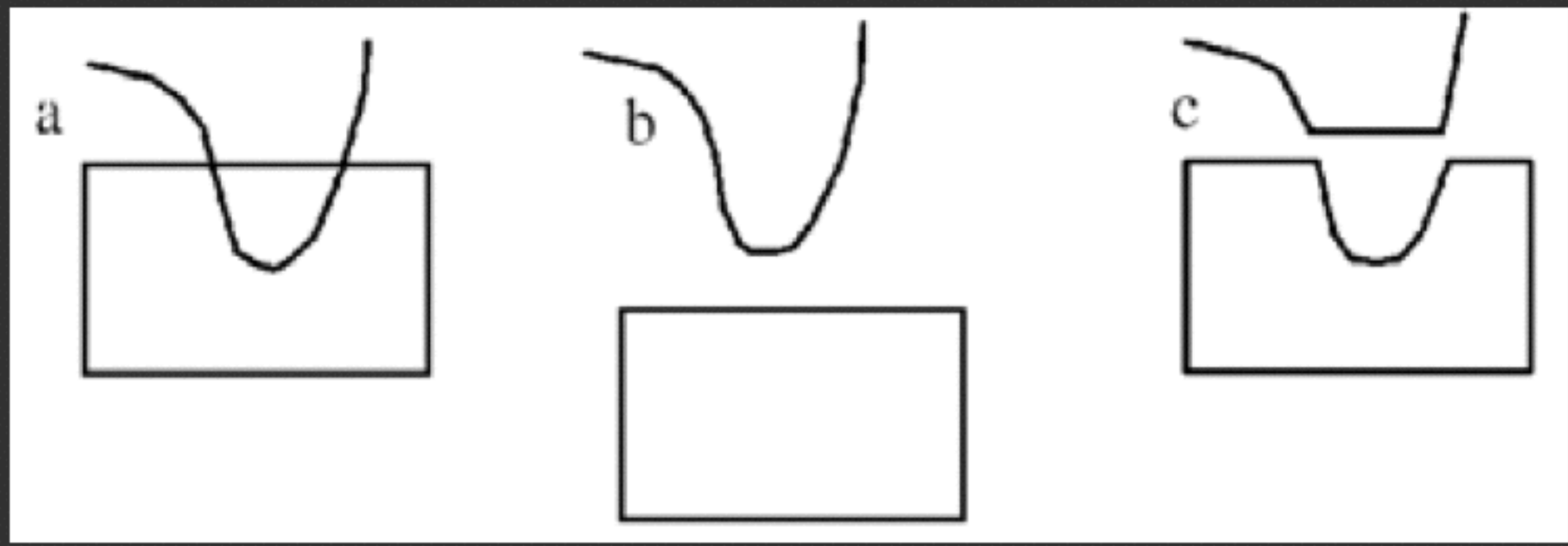


[Ware 00]

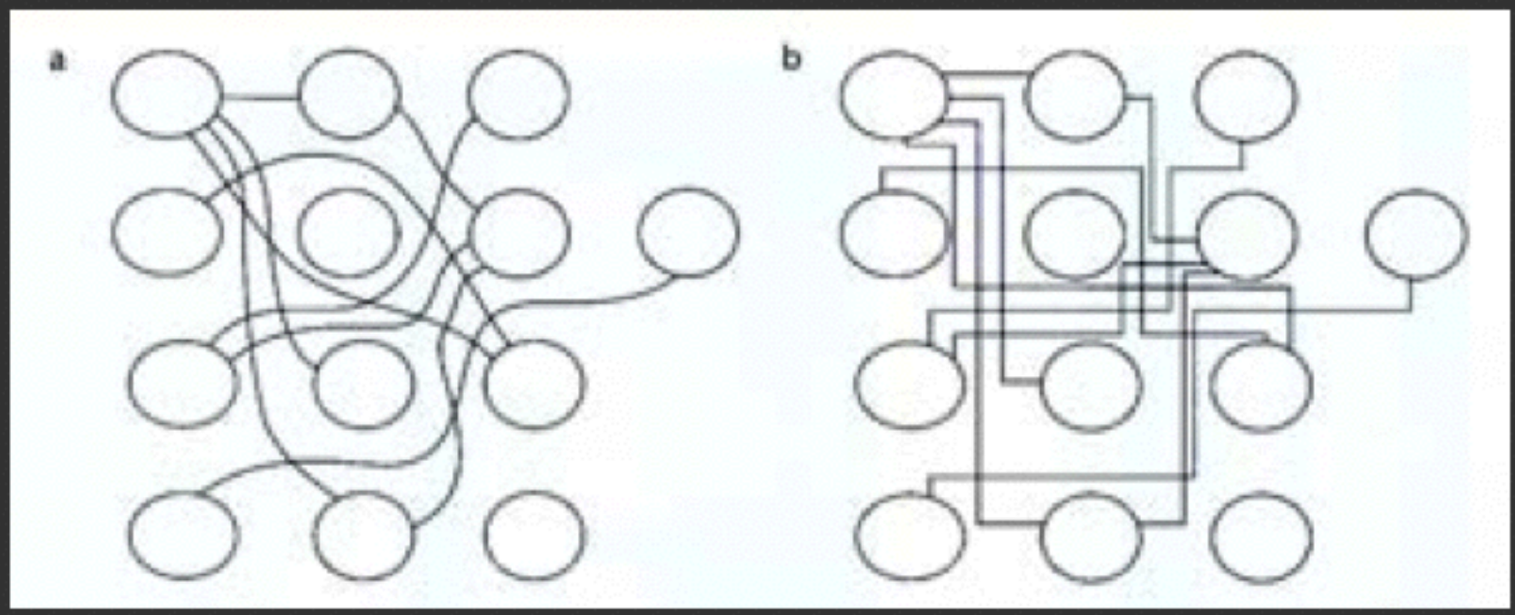

a
b



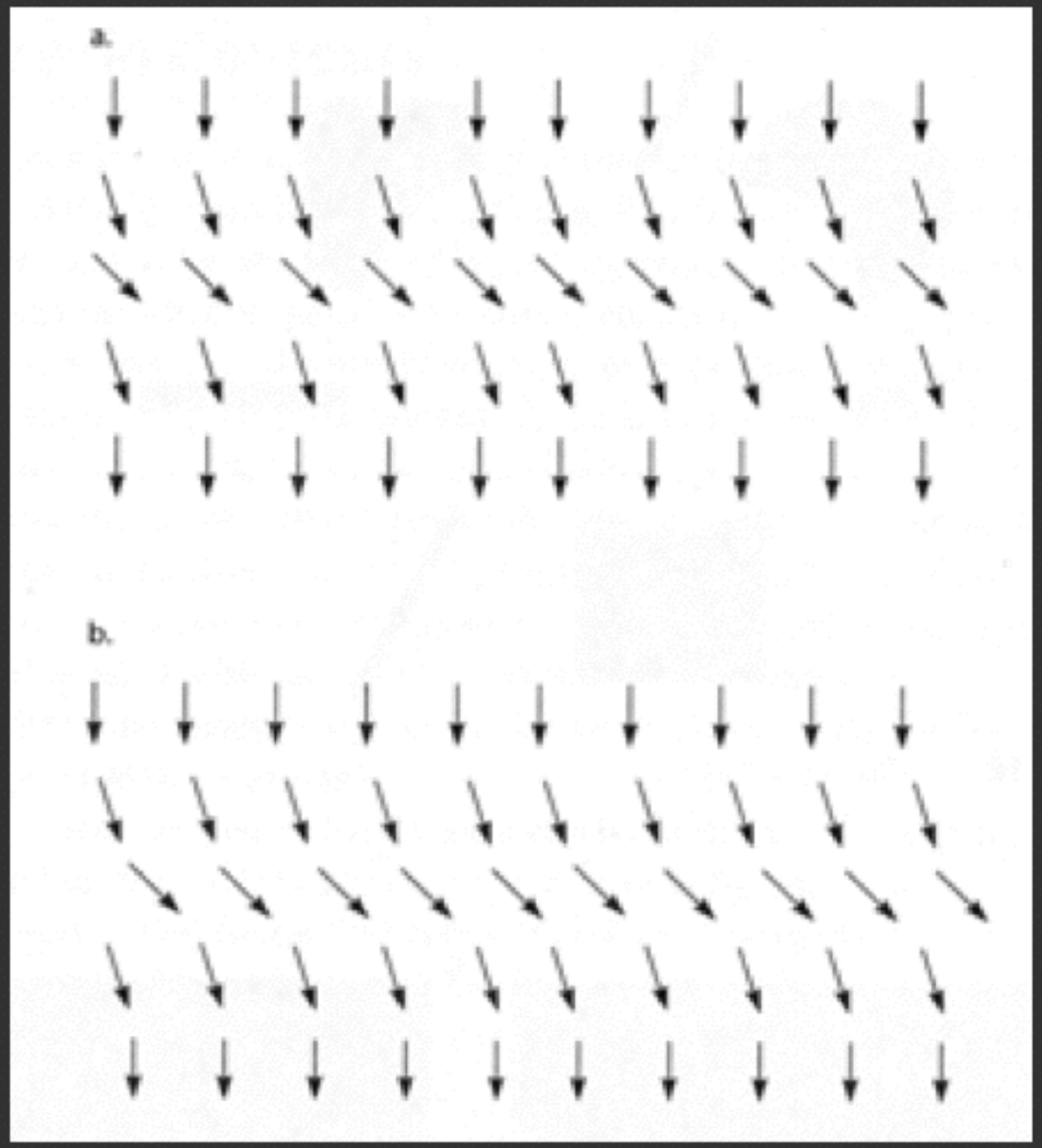

a
b
c
d



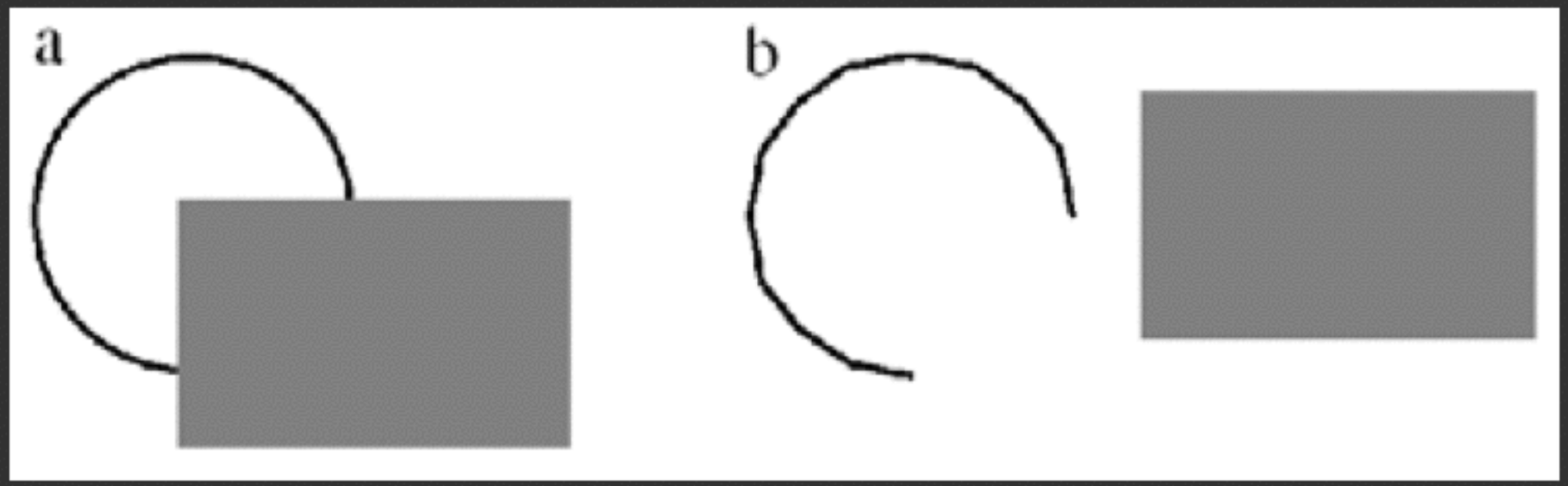
We prefer smooth not abrupt changes [from Ware 04]



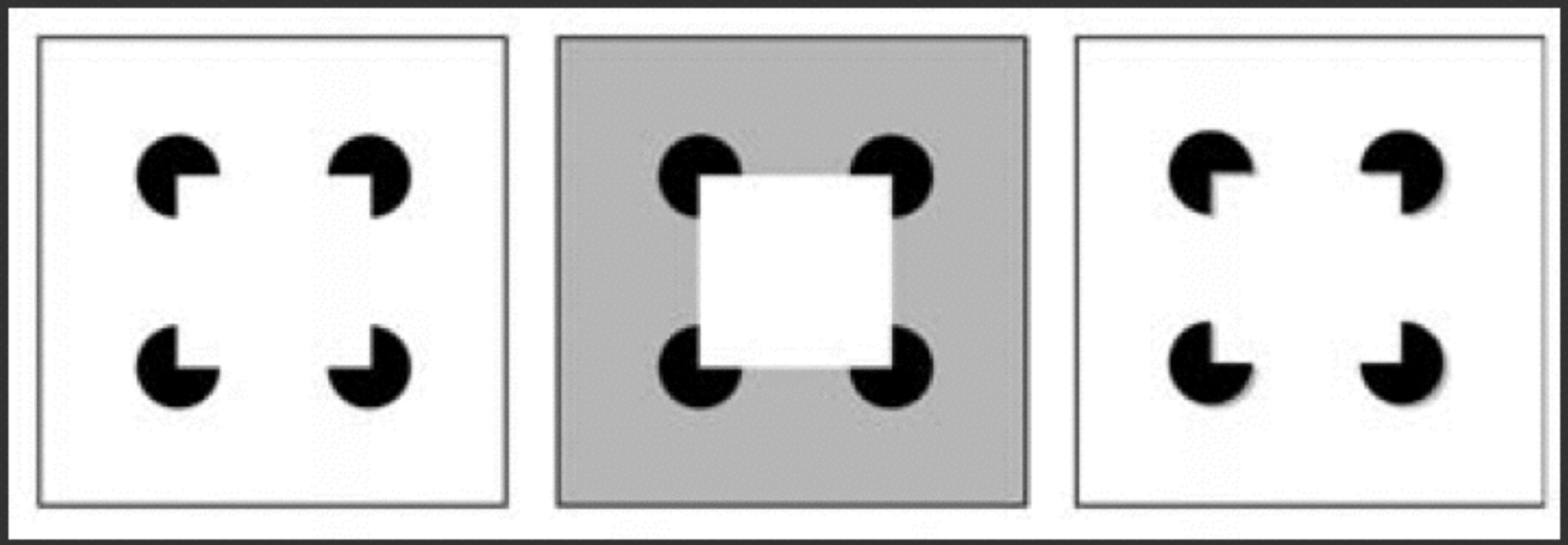
Connections are clearer with smooth contours [from Ware 04]



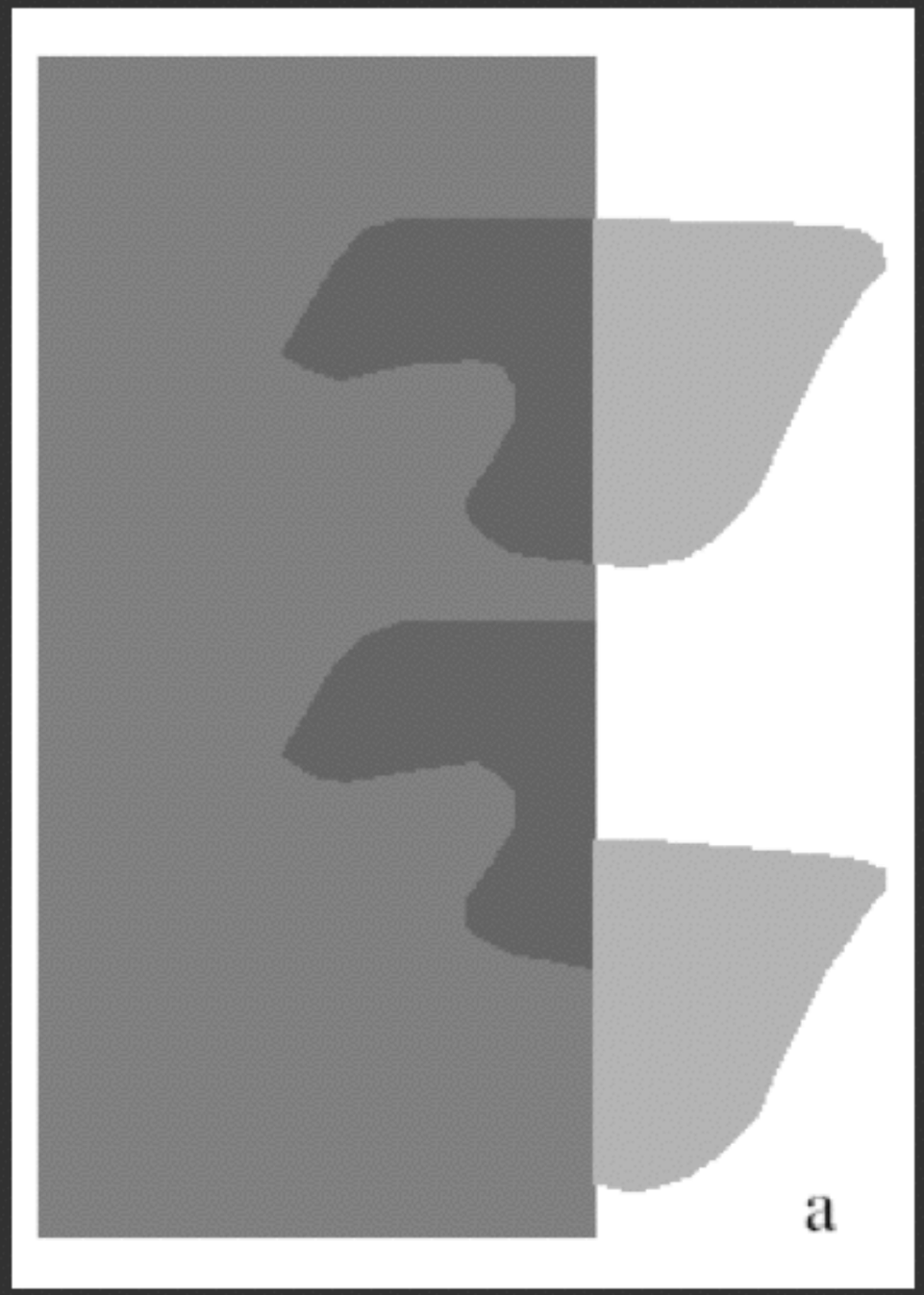
Prefer field that shows smooth continuous contours [from Ware 04]



We see a circle behind a rectangle, not a broken circle [from Ware 04]



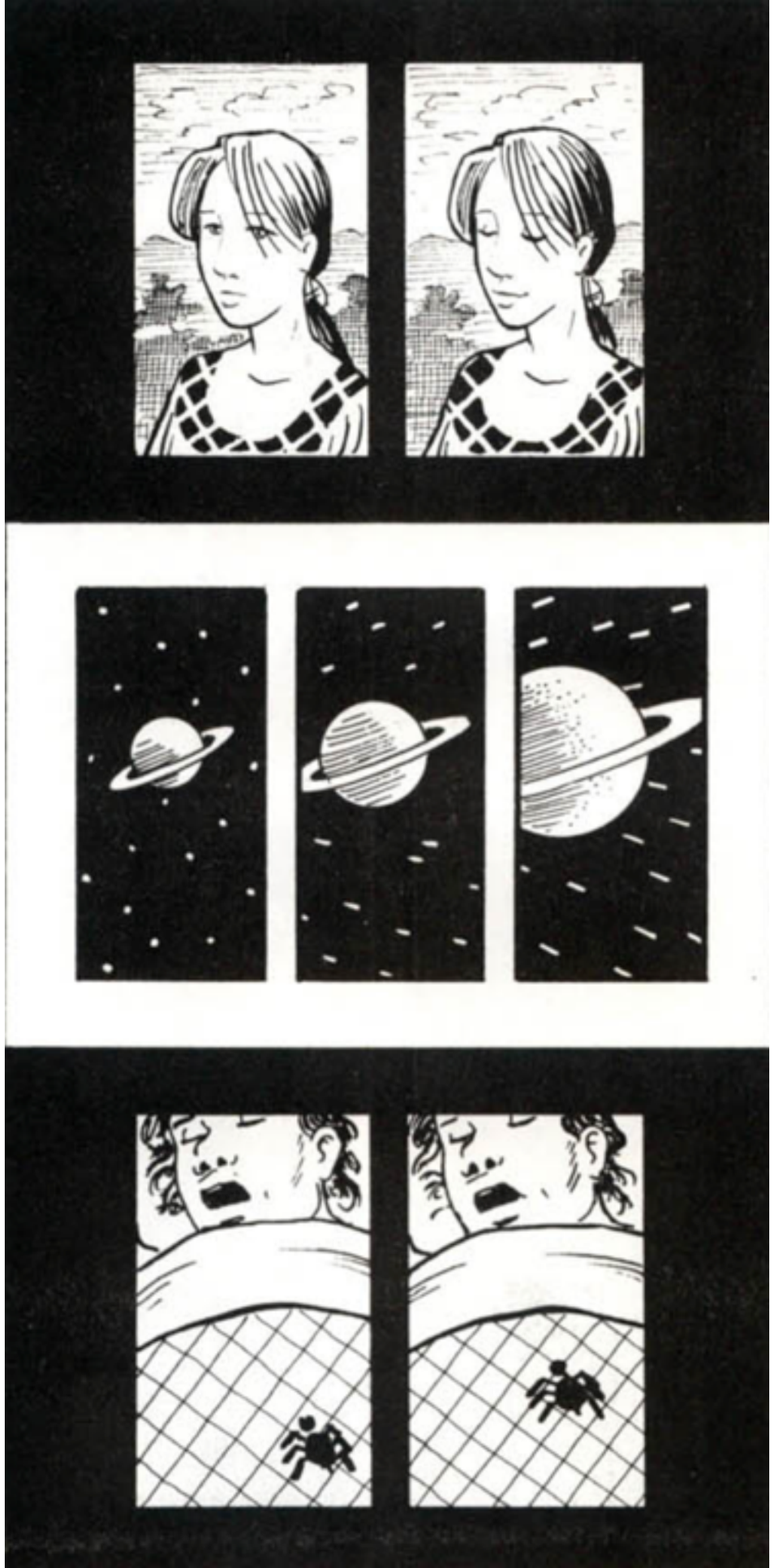
Illusory contours [from Durand 02]



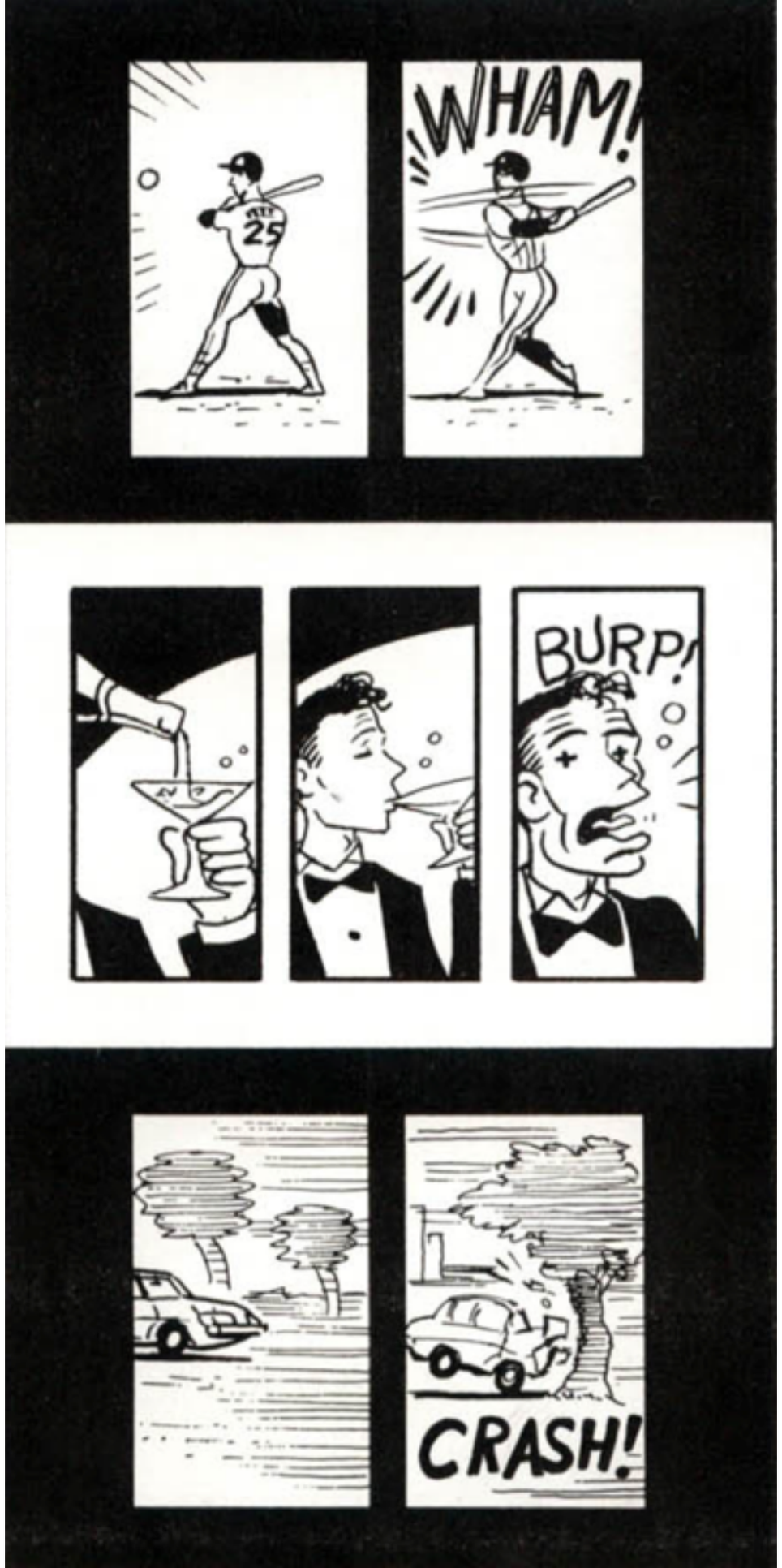
Requires continuity and proper color correspondence [from Ware 04]

Animation

Process, Dynamic, Causality



Moment to moment



Action to action

Subject to subject

Scene to scene

Aspect to aspect

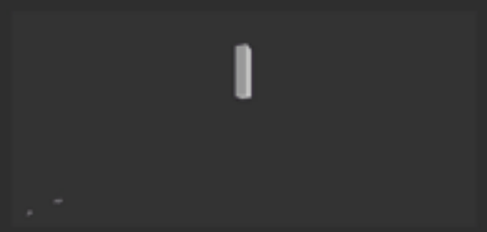
None

Example: Andre and Wally B.

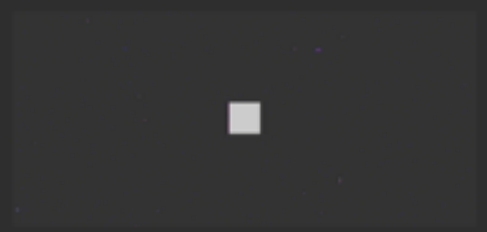
Example: Andre and Wally B.

Example: Andre and Wally B.

Example: Andre and Wally B.

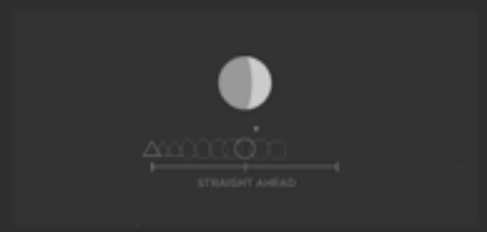


SQUASH & STRETCH



STAGING

ANTICIPATION

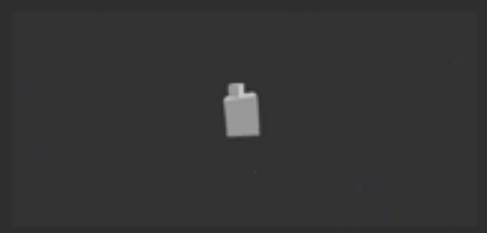


STRAIGHT AHEAD & POSE TO POSE

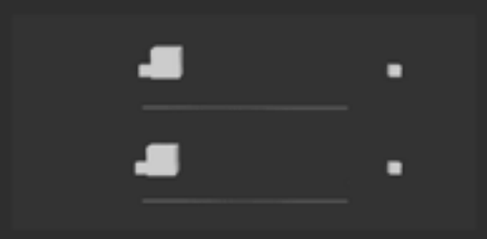
FOLLOW THROUGH & OVERLAPPING

SLOW IN & SLOW OUT

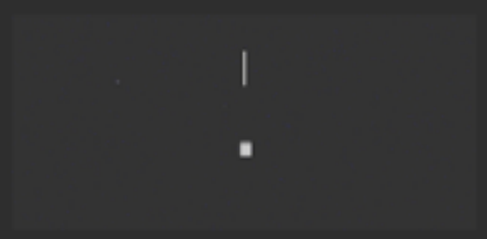
ARCS



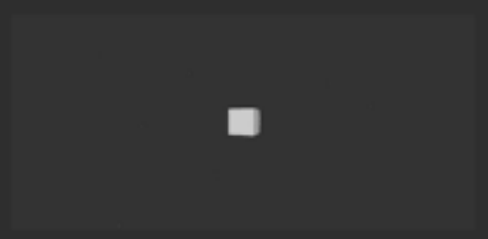
SECONDARY ACTION



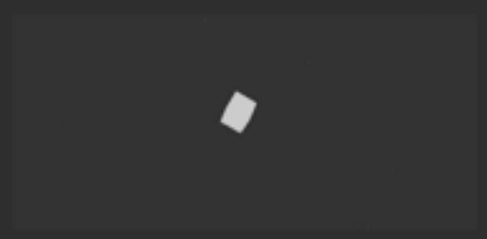
TIMING



EXAGGERATION



SOLID DRAWINGS

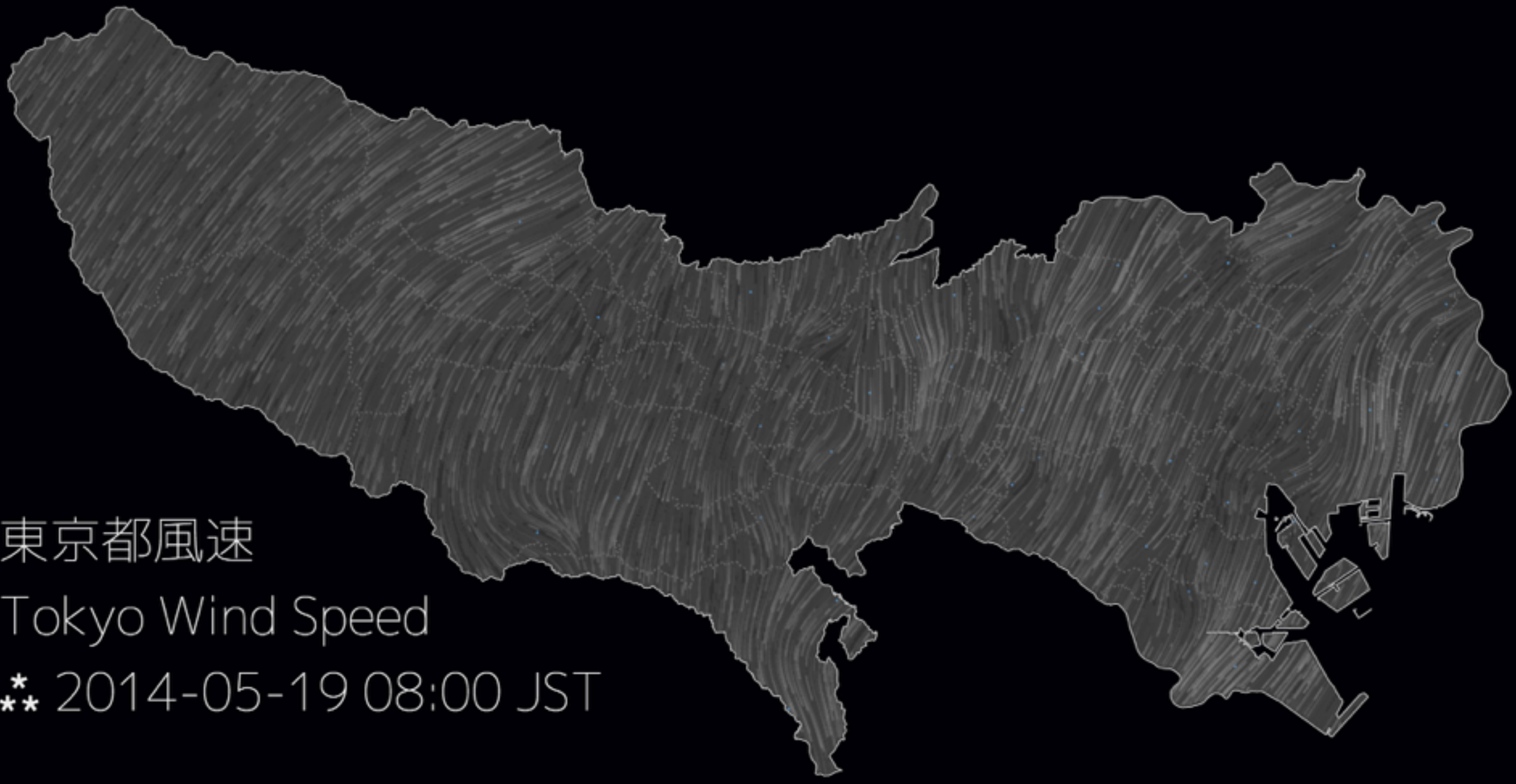


APPEAL

http://the12principles.tumblr.com/

http://ggruiz.me/explosions/

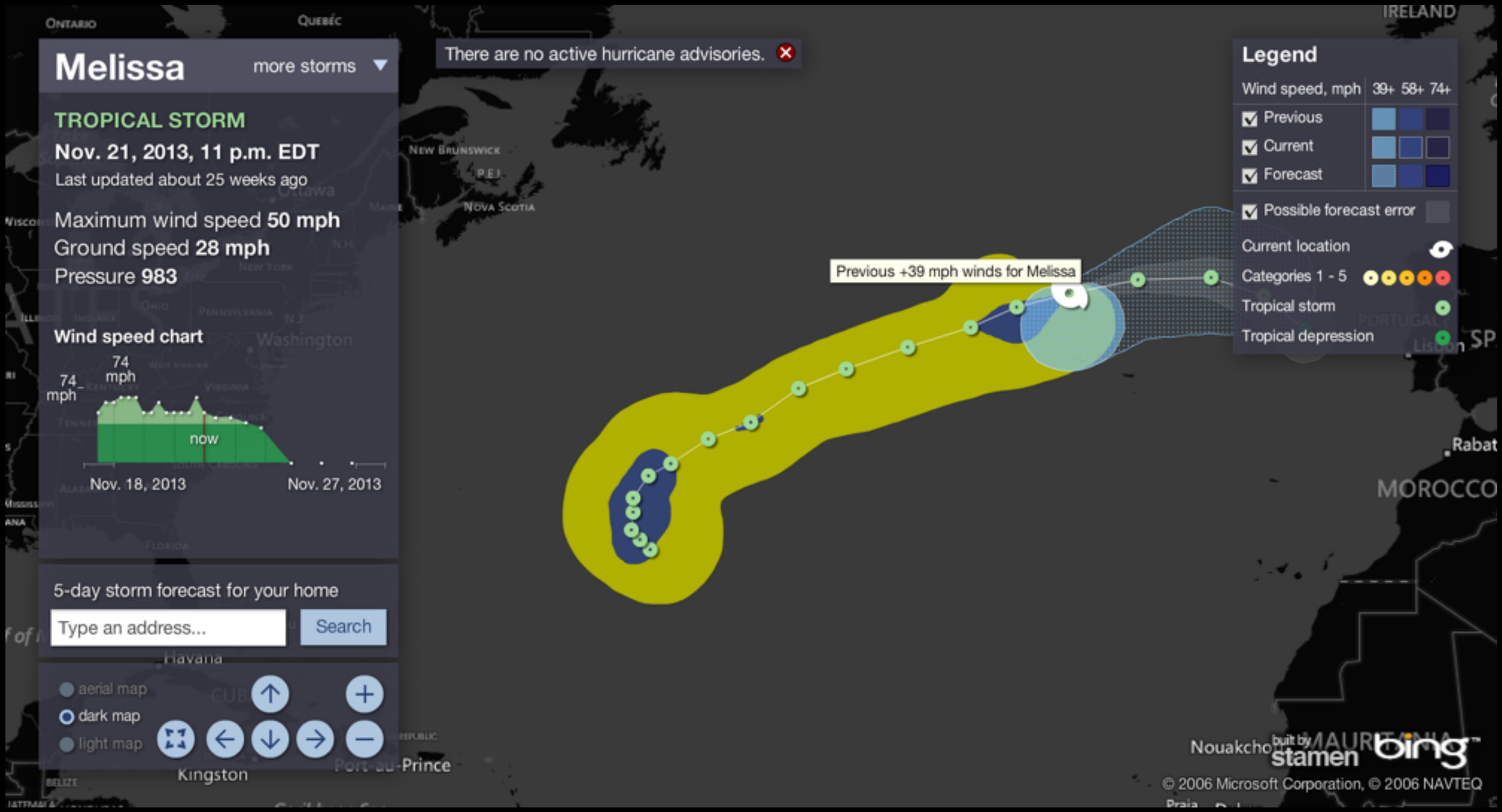
http://air.nullschool.net/



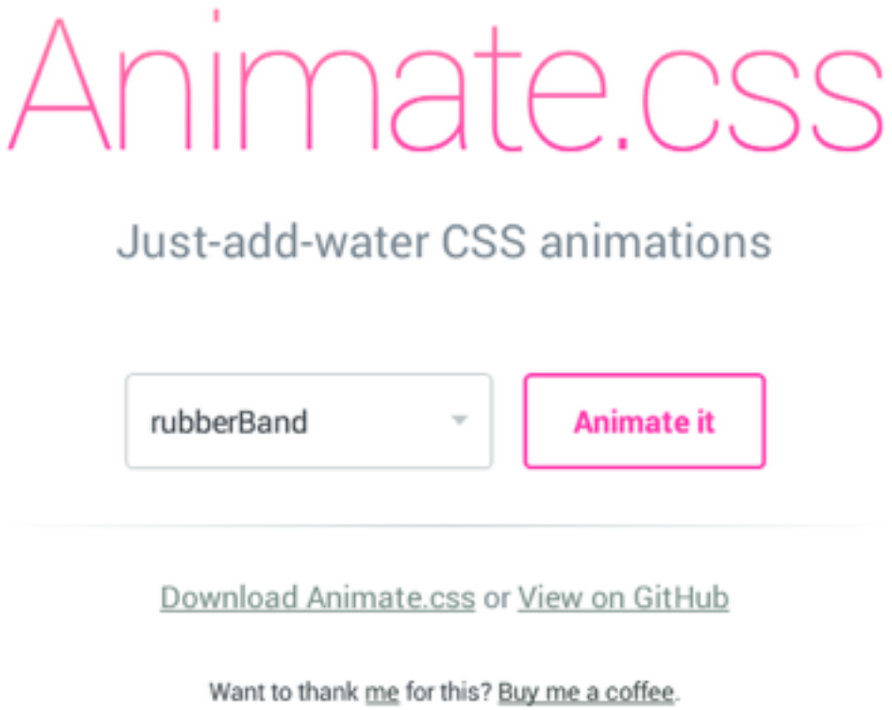
東京都風速

Tokyo Wind Speed

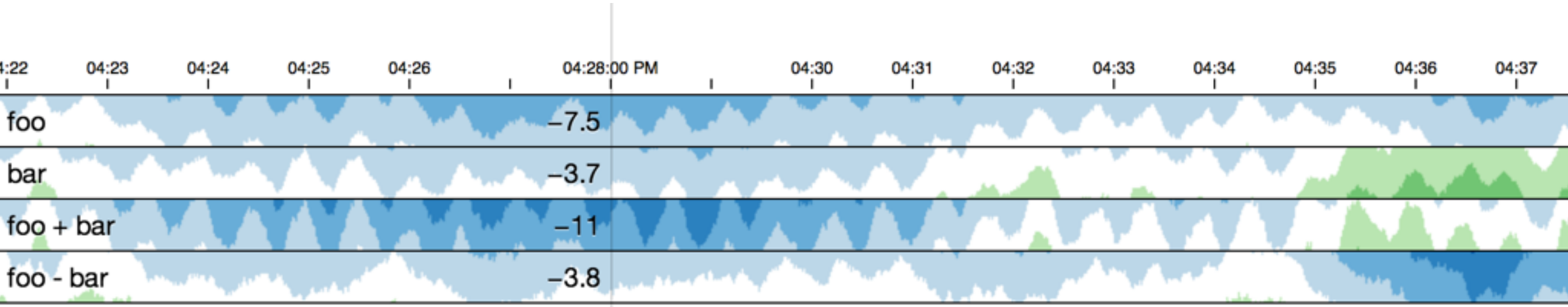
⁂ 2014-05-19 08:00 JST



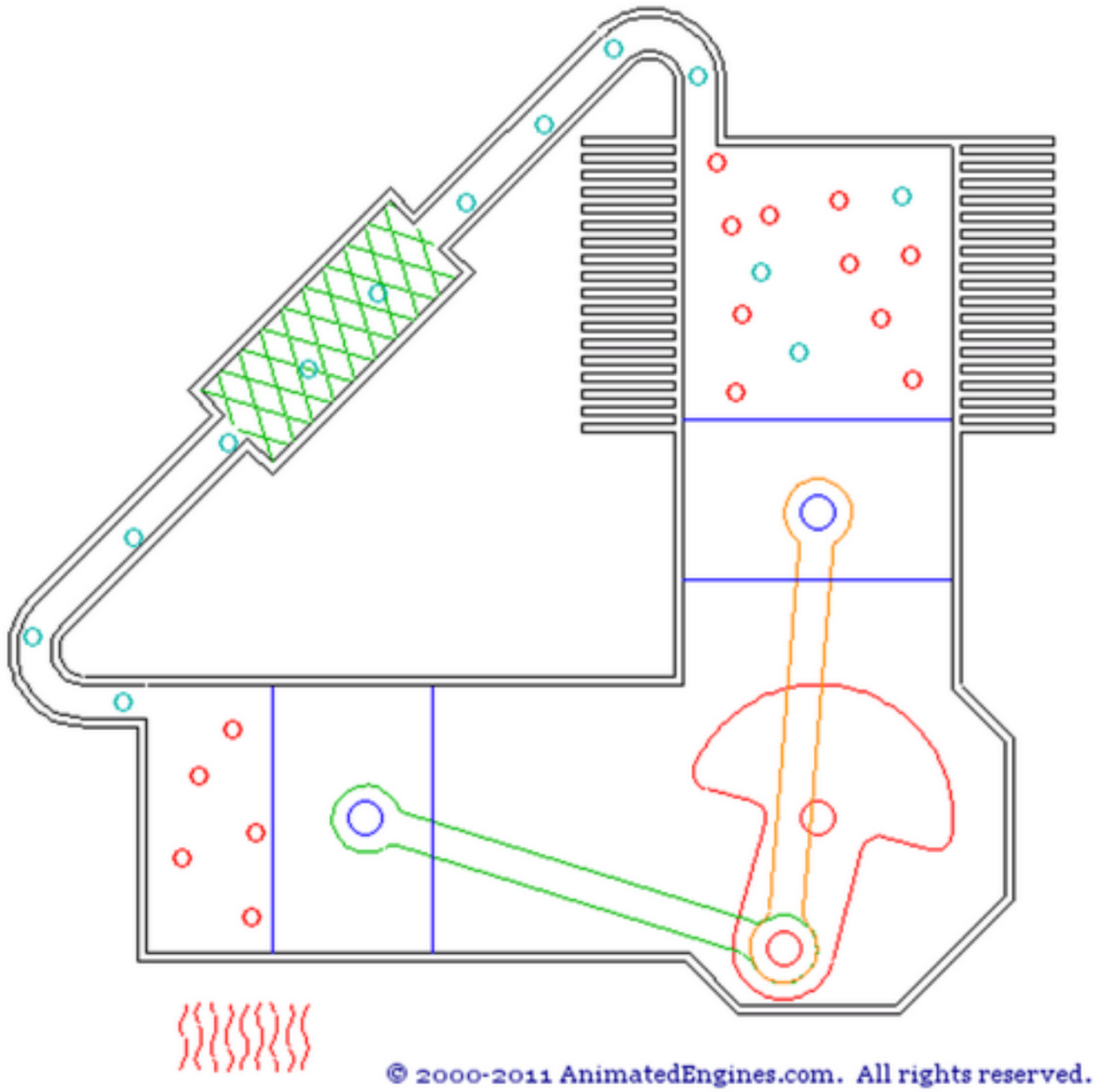
http://www.nbcnews.com/id/26295161/ns/weather/t/storm-tracker/#.U3kuZFhdWhs



http://daneden.github.io/animate.css/



http://square.github.io/cubism/



Interactivity

Selecting/highlighting, Brush,Linking, Sorting

Calvin Klein

A beautiful, innovative collection in which Francisco Costa layered references to urban tribes, ’80s art, handcraft and even, seemingly, radical chicks of the 1920s. It added up to a modern expression of fashion.

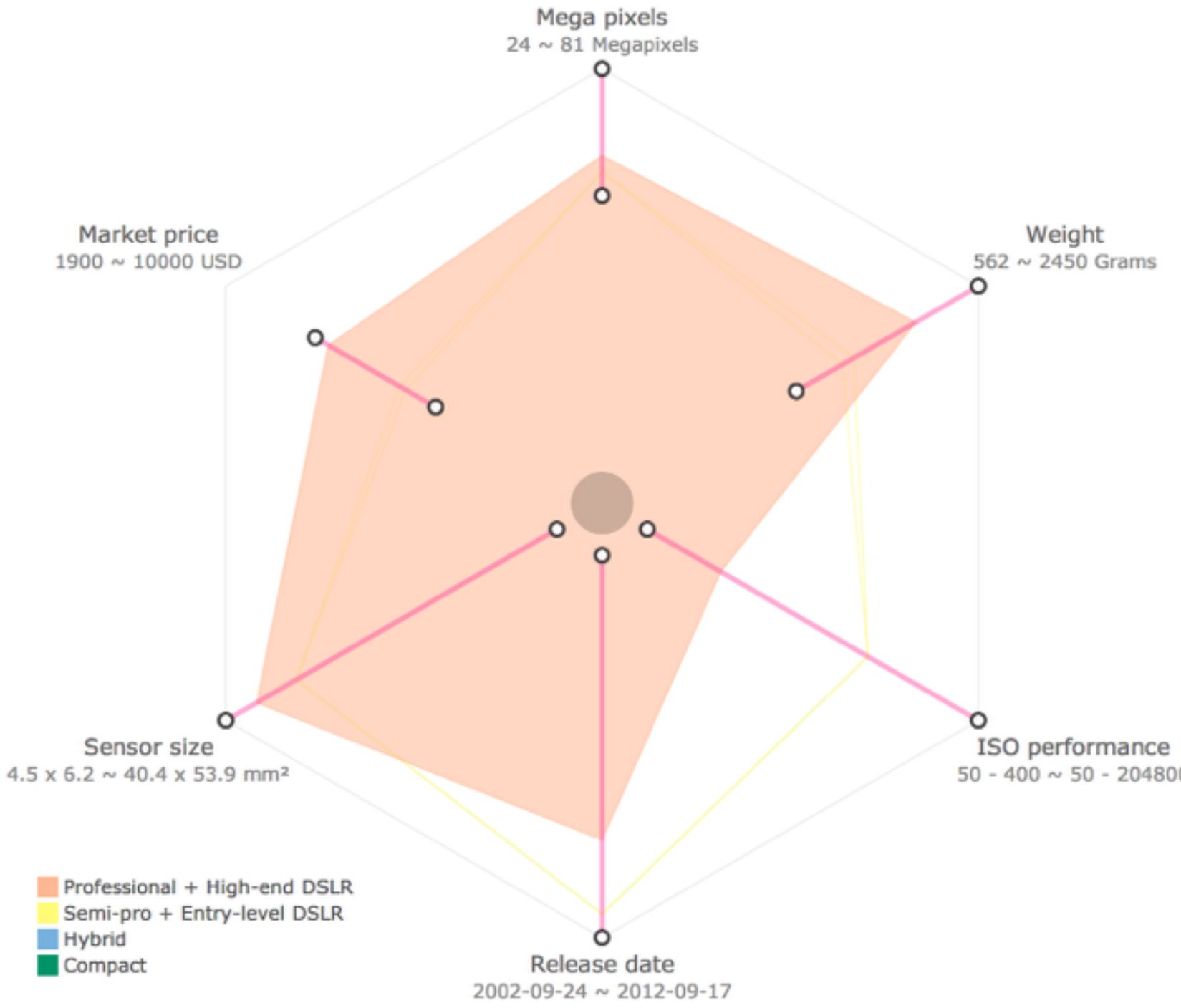
Read more: **Calvin Klein in Full Color**

Proenza Schouler

A challenging collection, inspired by the notion of home and interiors, it nonetheless showed the designers in a simpler vein.

Read more: **Pleats and Prints**

http://www.nytimes.com/newsgraphics/2013/09/13/fashion-week-editors-picks/



PENTAX
645D

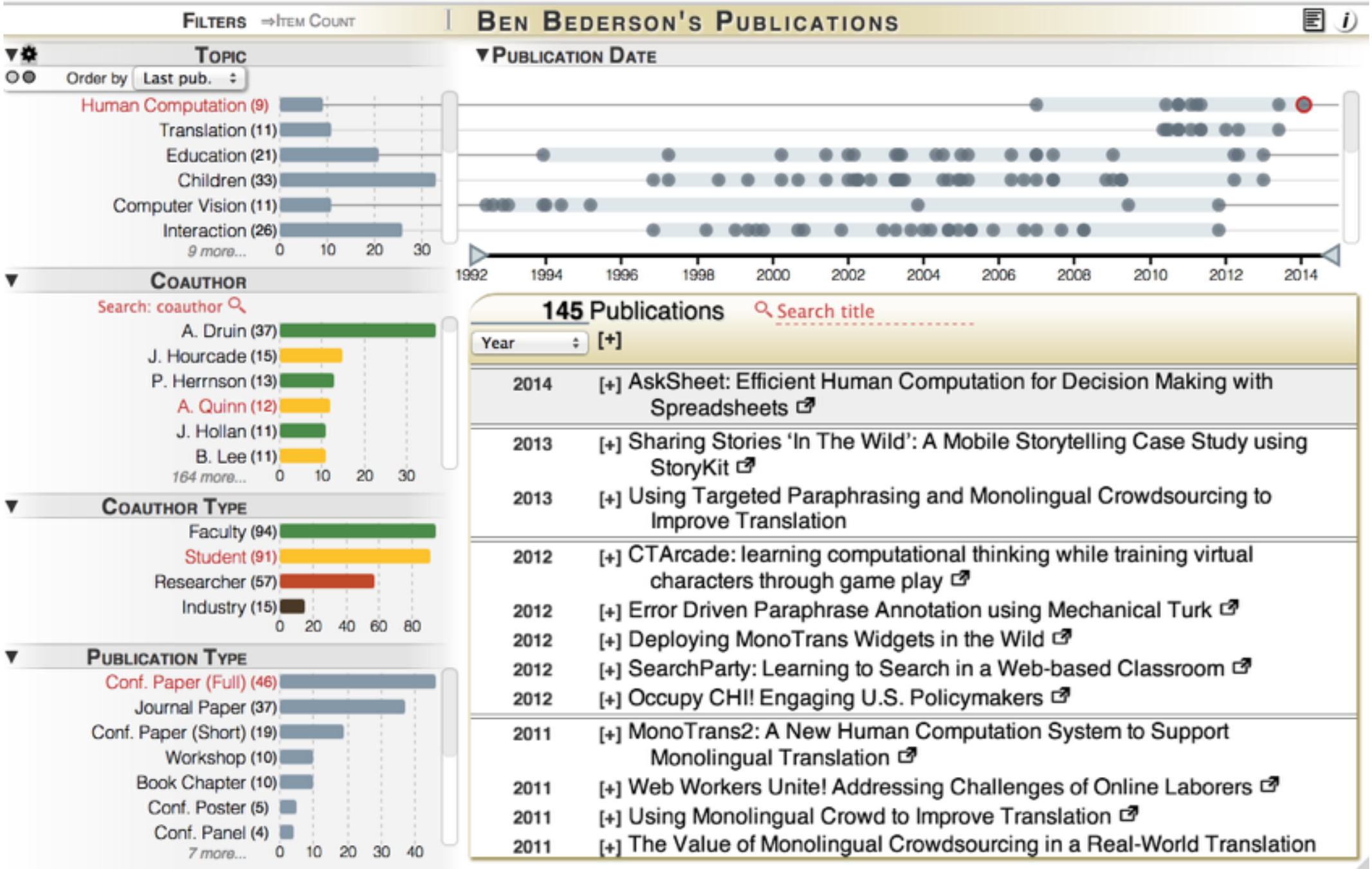
Brand	PENTAX
Model	645D
Type	Professional
MSRP	9400
Mpix	41
Frame	Medium format
Release	2010-03-01
Sensor type	CCD
Resolution	7424 x 5552
Sensor Size	33.0 x 44.0
Color filter array	RGB
Pixel pitch	5.93
Bits per pixel	14
Focal length multipler	0.78
Aspect ratio	4:3
ISO latitude	100 - 1600
Shutter type	mechanical
Fastest - Slowest speed	1/4000 - 30
Frame rate	1.1
Live view	yes
Stablization	N/A
Weight	1480

http://bwang29.github.io/offshore/camera_vis/

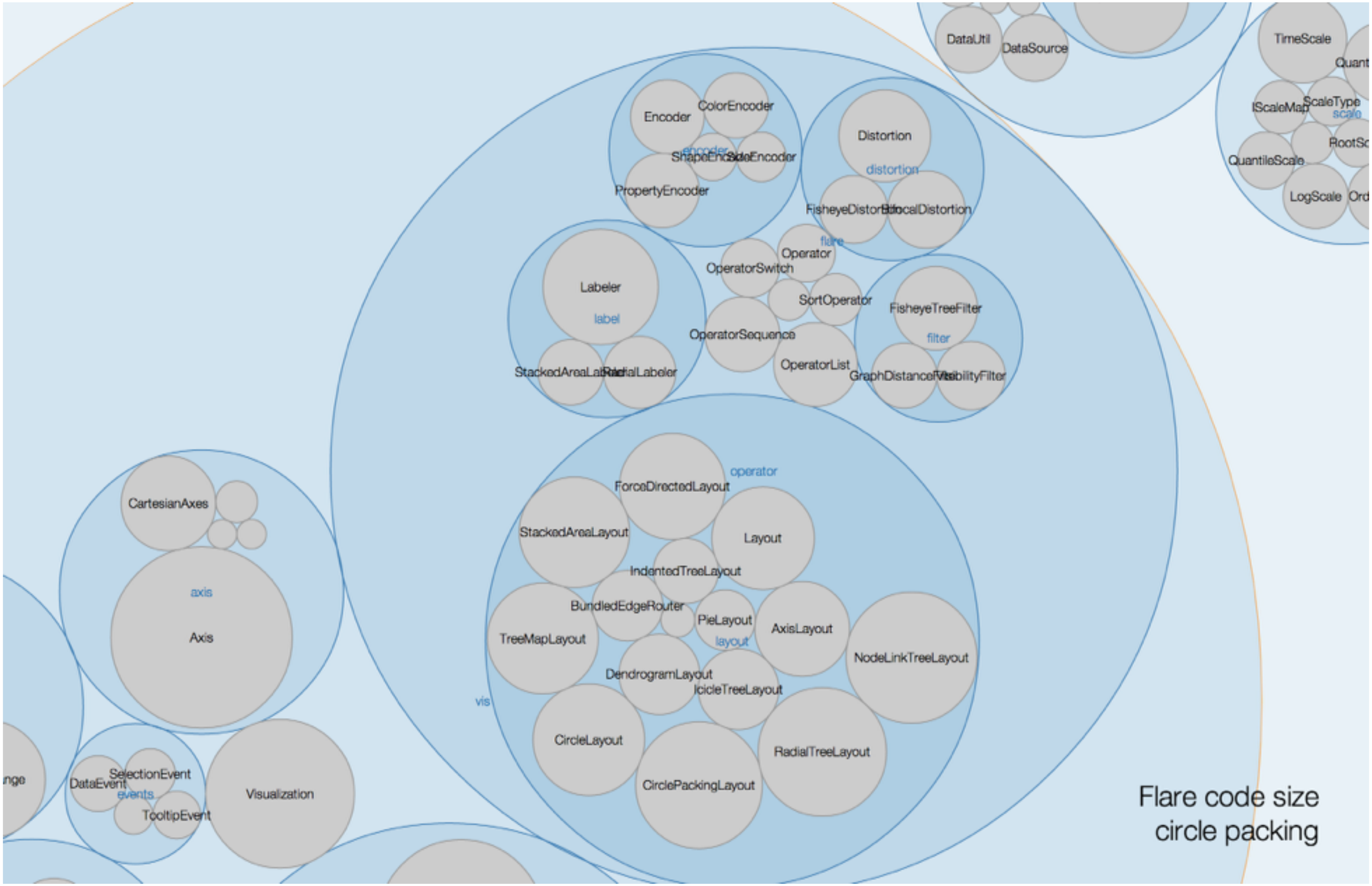
http://benfry.com/zipdecode/

Ben Bederson

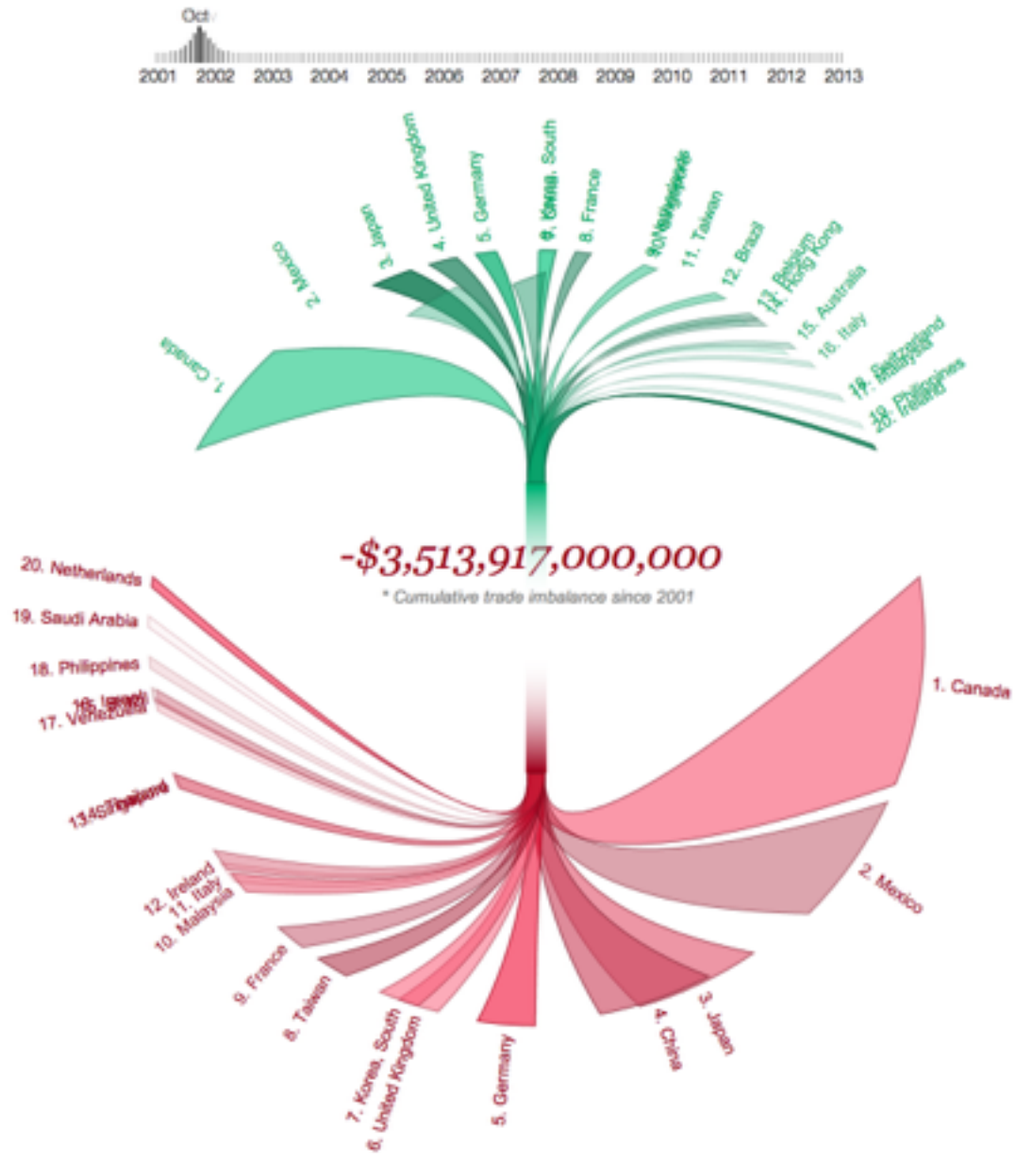
Created by Keshif. Click for more...



http://www.cs.umd.edu/~bederson/papers/index.html



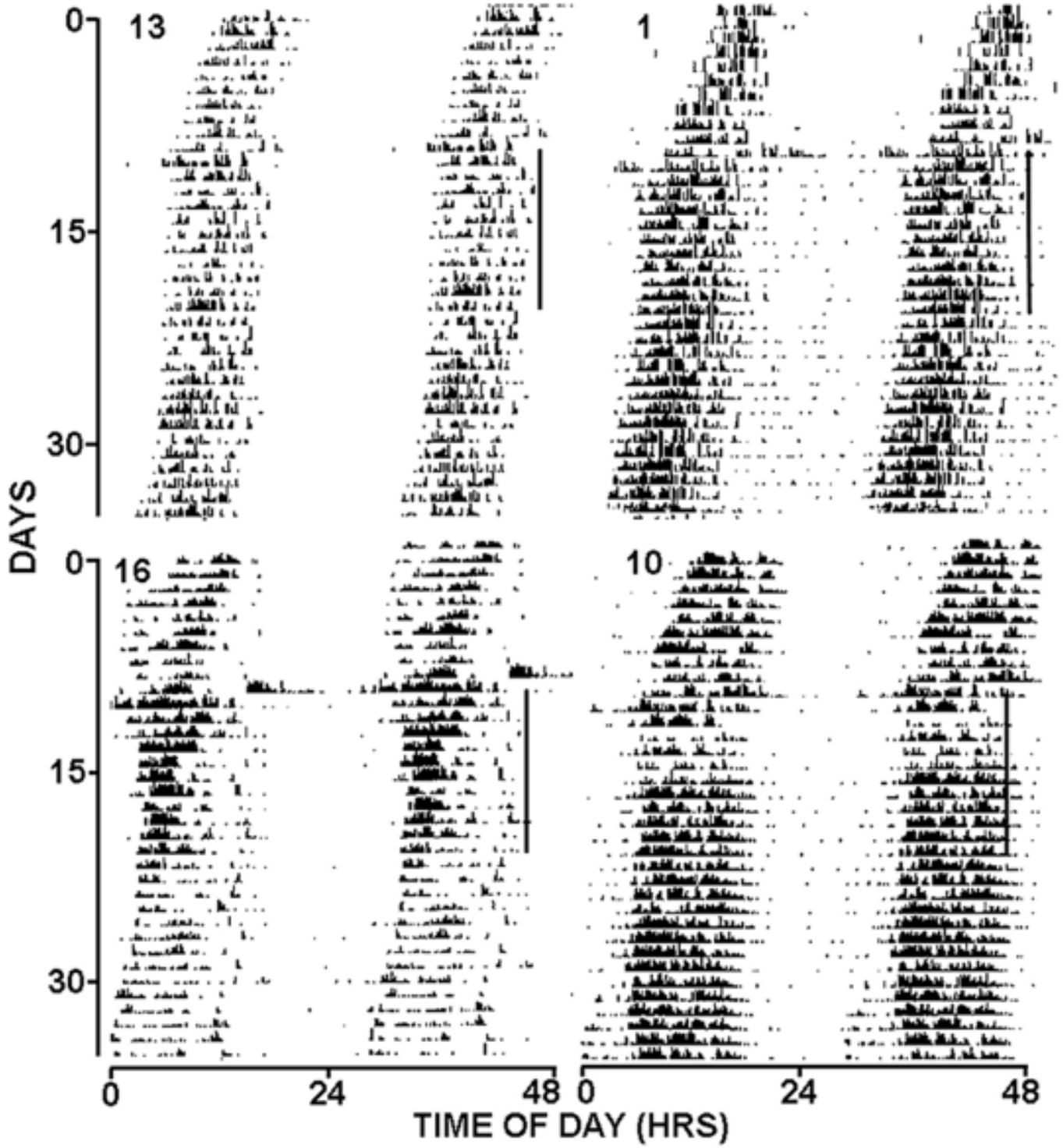
http://mbostock.github.io/d3/talk/20111116/pack-hierarchy.html



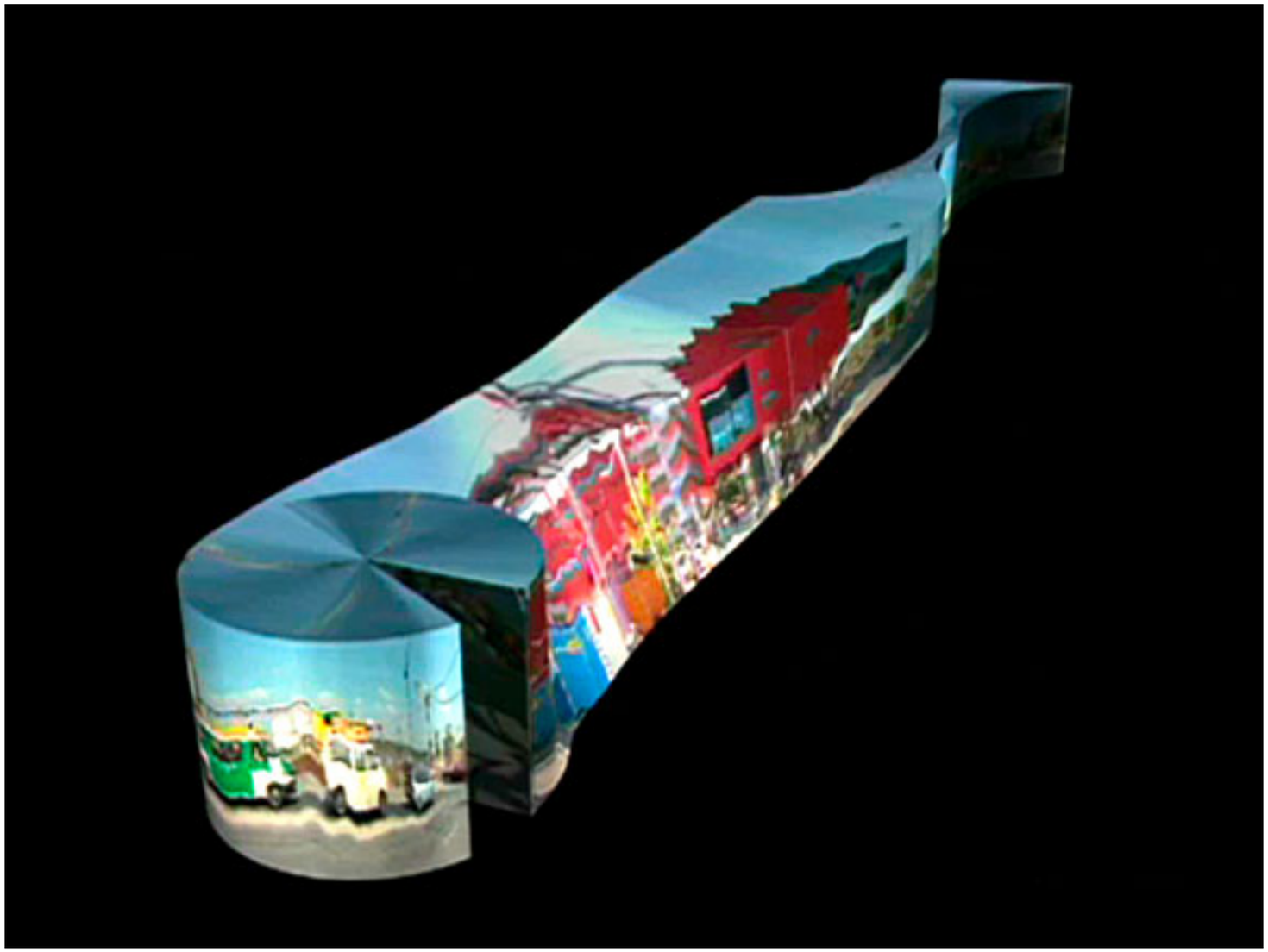
http://www.brightpointinc.com/interactive/ustrade/index.html?source=d3js

Digression Visualize Time

Actogram

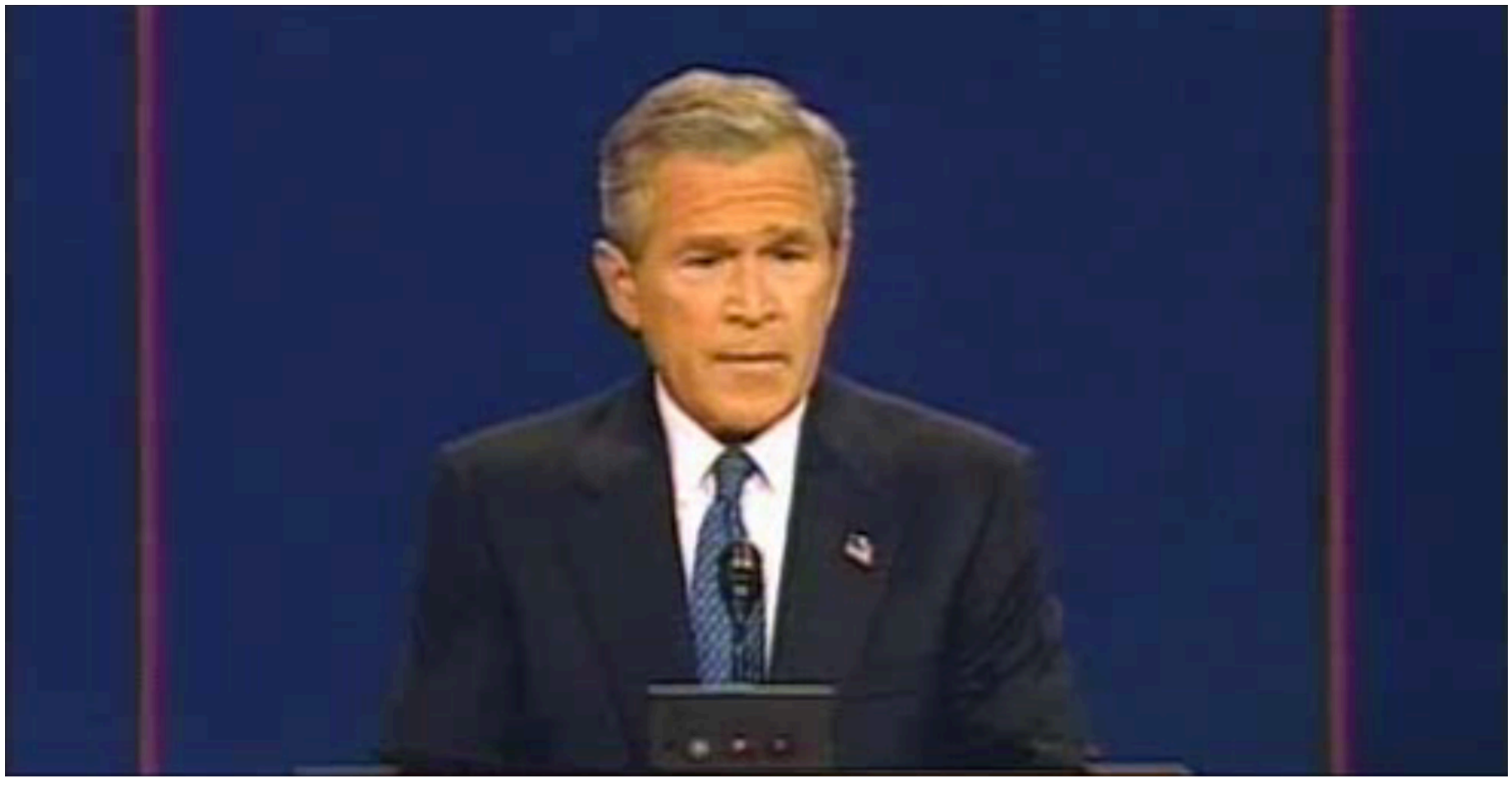


Visualizing Time - Space to Time matching



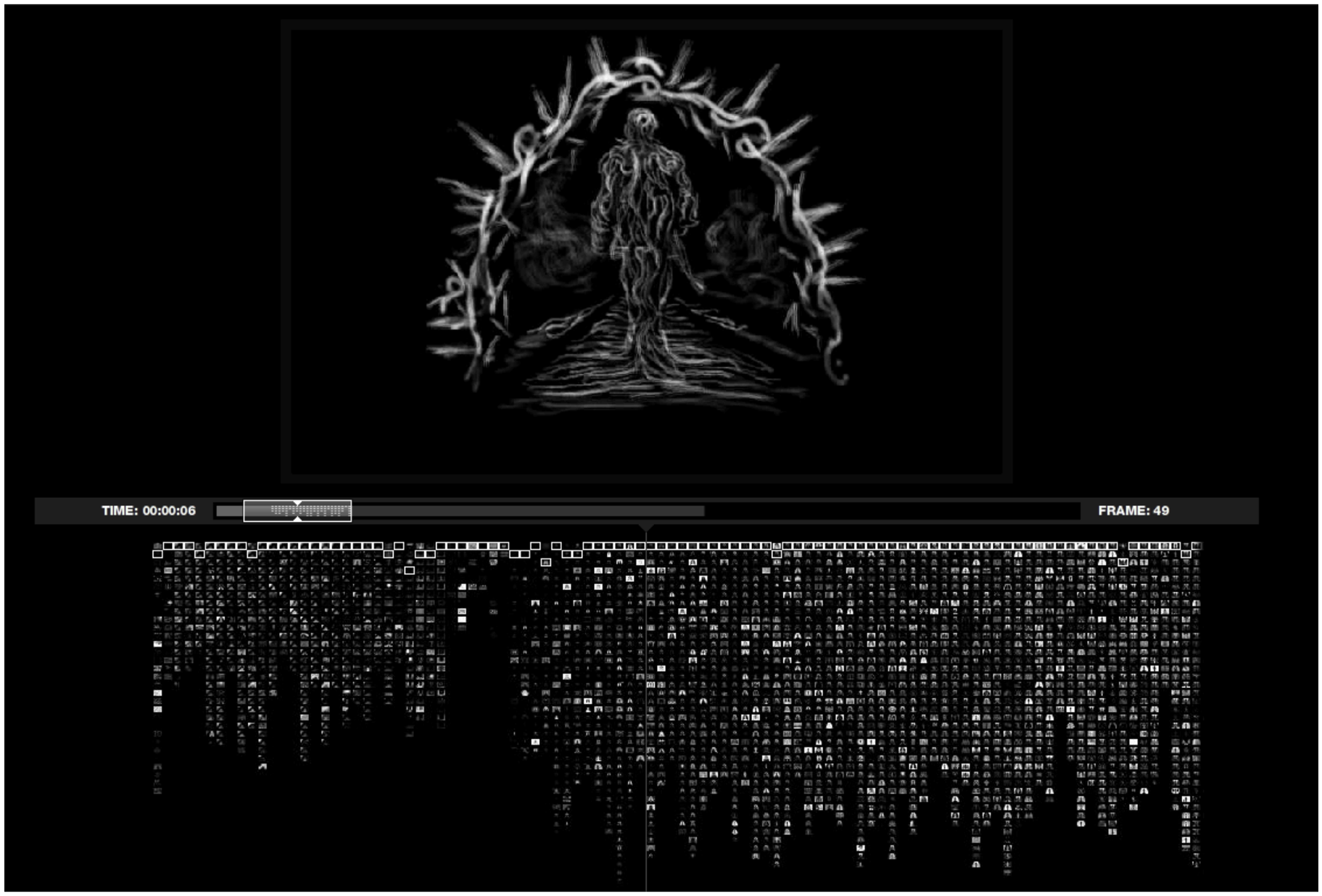
http://www.artcom.de/en/projects/project/detail/the-invisible-shape-of-things-past/

Visualizing Time - Intervals and Splitting



http://vimeo.com/1962465

Visualizing Time - Frames



http://www.thejohnnycashproject.com/#/explore/TopRated

Visualizing Time - Continuity

https://www.youtube.com/watch?v=pXPP8eUlEtk

D3

Is basically a SVG selection, decoration, positioning, and animation library

http://d3js.org/

Chart Typologies

Excel, Many Eyes, Google Charts

Visual Analysis Languages

Tableau VizQL, ggplot2, HiVE

Declarative Encoding Languages

Protovis, D3

Component Model Architectures

Improvise, Prefuse, Flare

Graphics APIs

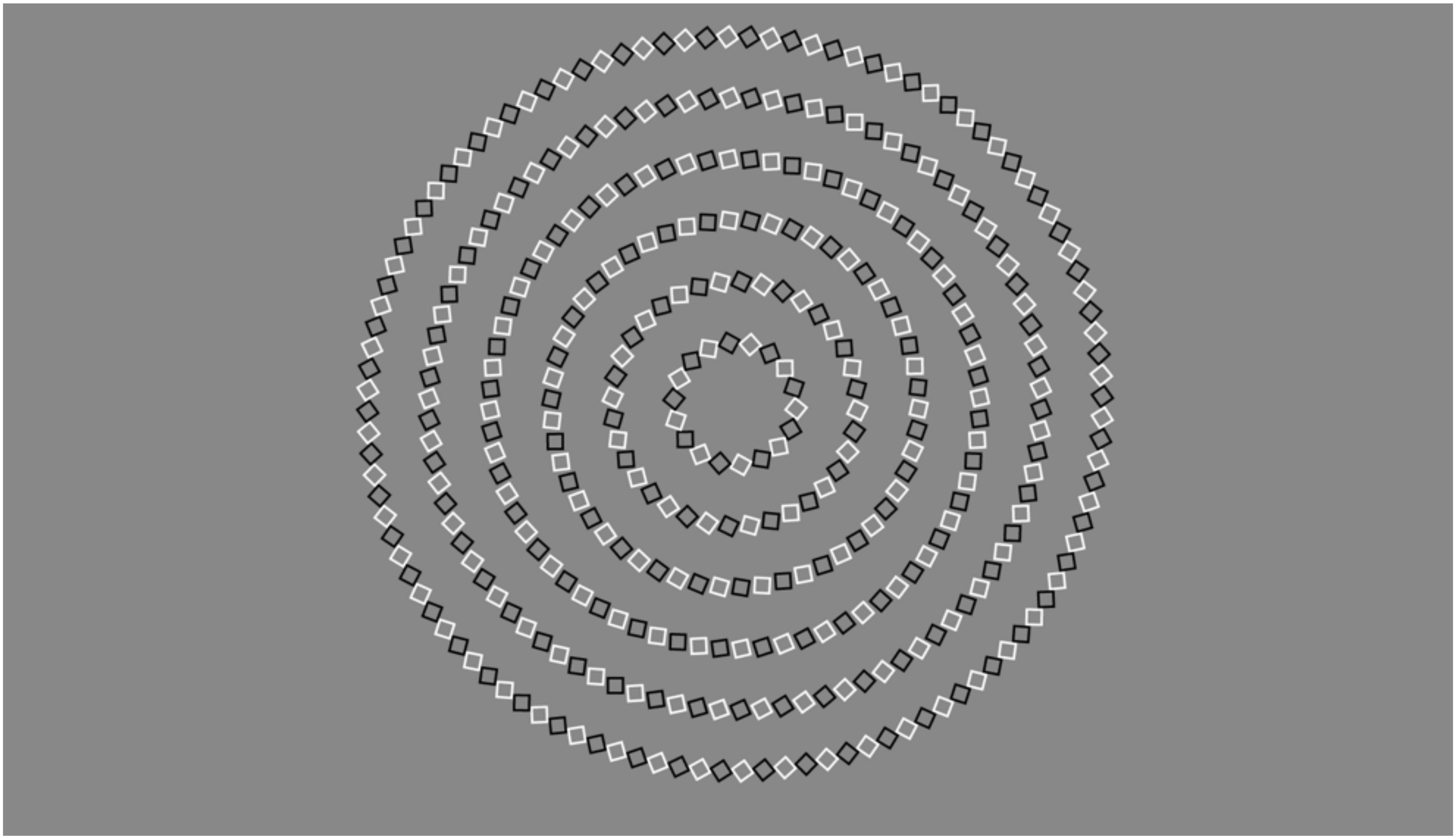
OpenGL, Java2D, GDI+, Processing

Efficiency

Expressiveness

Just learn by looking at the samples..

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



```
var w = 960,
    h = 500,
    start = Date.now();

var rings = [
  {radius: 65 * 1, width: 16, speed: -3e-2},
  {radius: 65 * 2, width: 16, speed: -2e-2},
  {radius: 65 * 3, width: 16, speed: -1e-2},
  {radius: 65 * 4, width: 16, speed: 1e-2},
  {radius: 65 * 5, width: 16, speed: 2e-2},
  {radius: 65 * 6, width: 16, speed: 3e-2}
];

var svg = d3.select("body").append("svg:svg")
    .attr("width", w)
    .attr("height", h)
  .append("svg:g")
    .attr("transform", "translate(" + w / 2 + "," + h / 2 + ")scale(.6)");

var ring = svg.selectAll("g")
    .data(rings)
  .enter().append("svg:g")
    .attr("class", "ring")
    .each(ringEnter);
```

```
d3.timer(function() {
  var elapsed = Date.now() - start,
      rotate = function(d) { return "rotate(" + d.speed * elapsed + ")"; };

  ring
      .attr("transform", rotate)
    .selectAll("rect")
      .attr("transform", rotate);
});

function ringEnter(d, i) {
  var n = Math.floor(2 * Math.PI * d.radius / d.width * Math.SQRT1_2),
      k = 360 / n;

  d3.select(this).selectAll("g")
      .data(d3.range(n).map(function() { return d; }))
    .enter().append("svg:g")
      .attr("class", "square")
      .attr("transform", function(_, i) { return "rotate(" + i * k + ")translate(" + d.radiu
    .append("svg:rect")
      .attr("x", -d.width / 2)
      .attr("y", -d.width / 2)
      .attr("width", d.width)
      .attr("height", d.width);
}
```