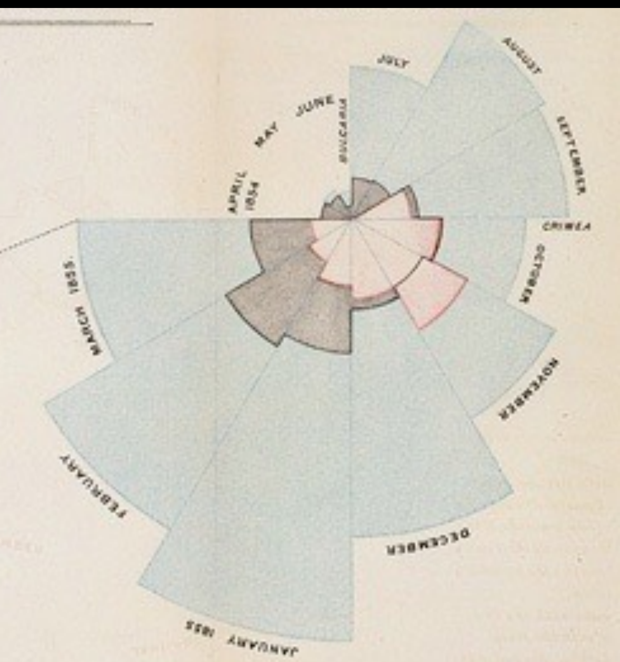
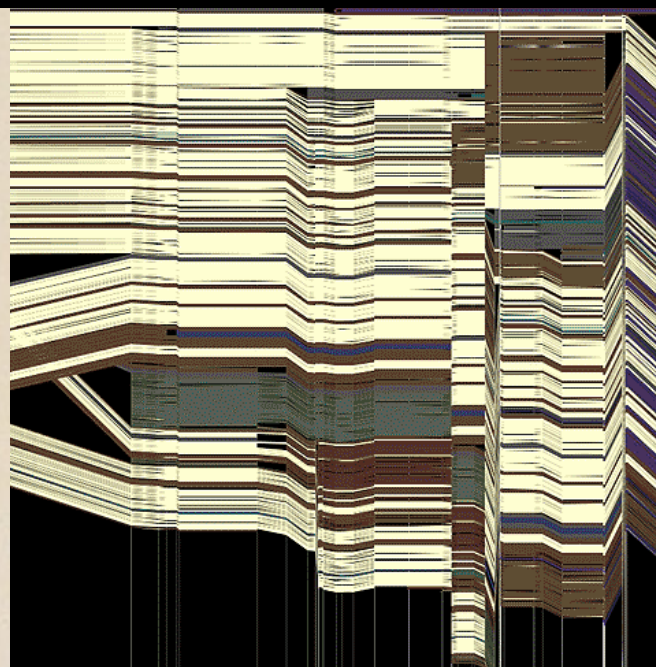
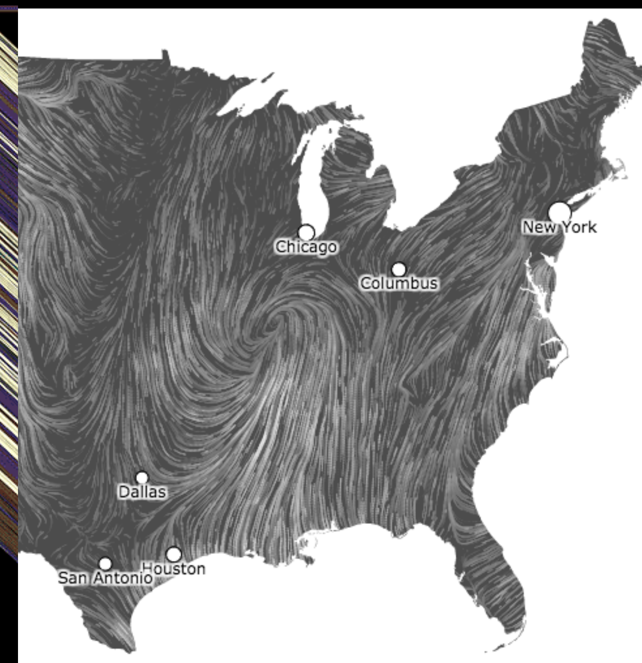
CSE 512 - Data Visualization

Visualization Tools







Jeffrey Heer University of Washington

How do people create visualizations?

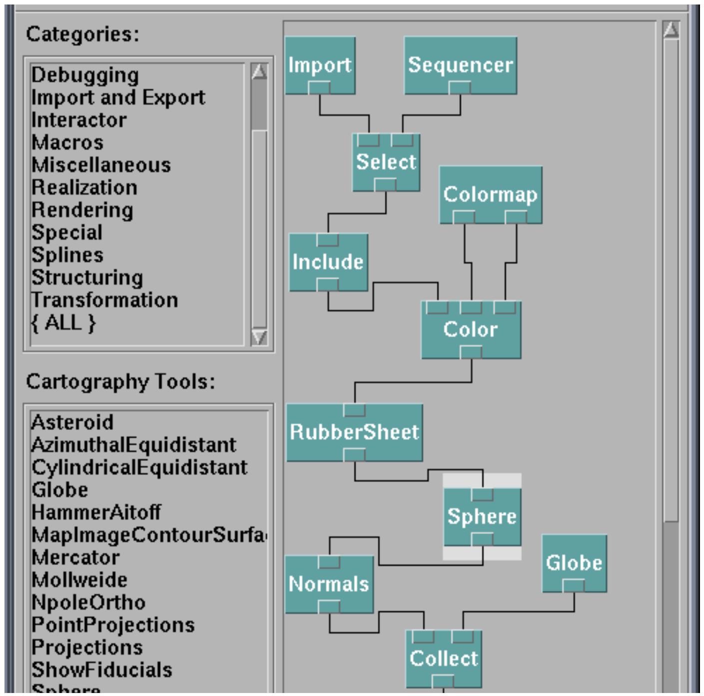


Chart Typology

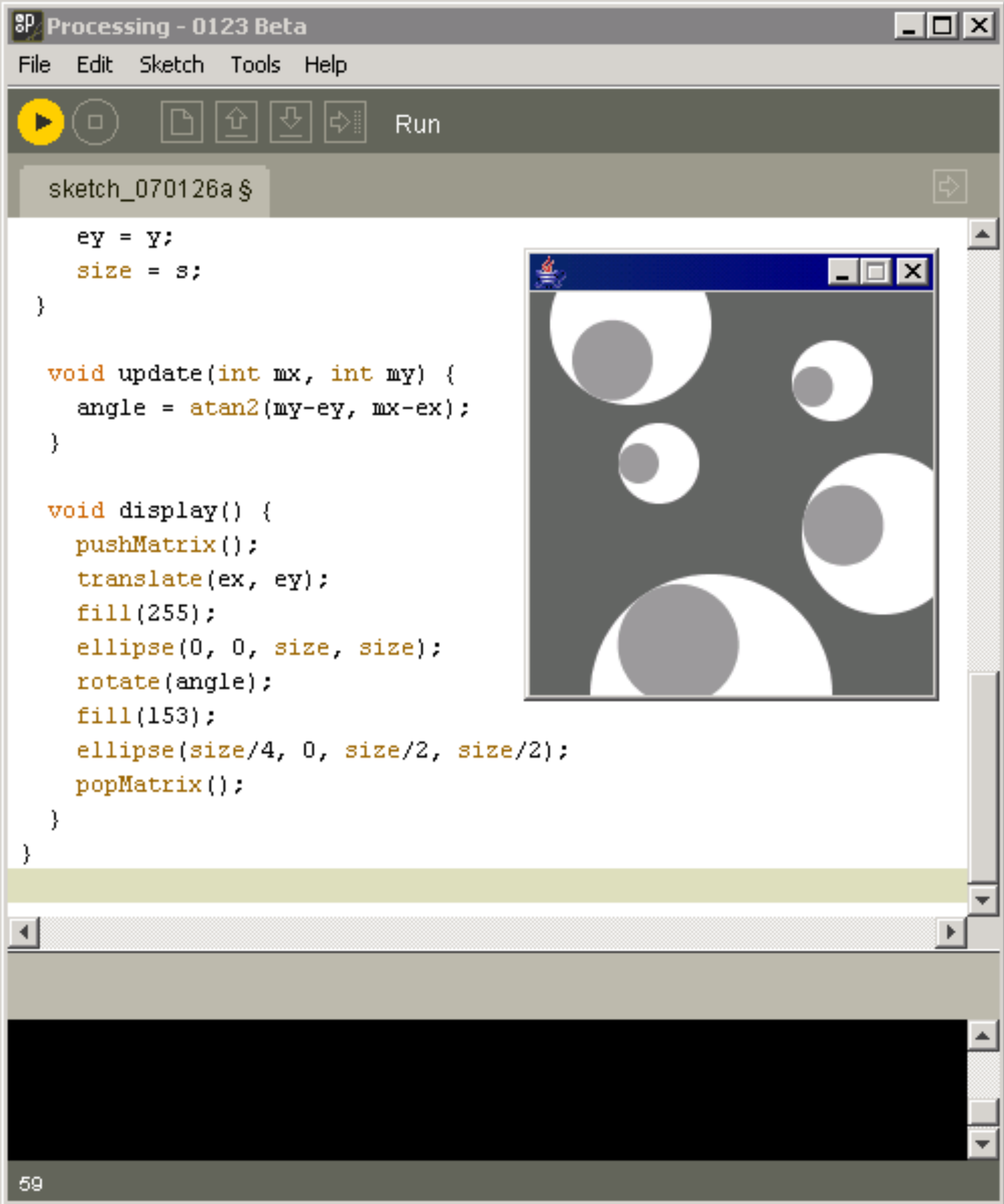
Pick from a stock of templates
Easy-to-use but limited expressiveness
Prohibits novel designs, new data types

Component Architecture

Permits more combinatorial possibilities
Novel views require new operators,
which requires software engineering

Graphics APIs

Canvas, OpenGL, Processing



http://processing.org

US Air Traffic, Aaron Koblin

Graphics APIs

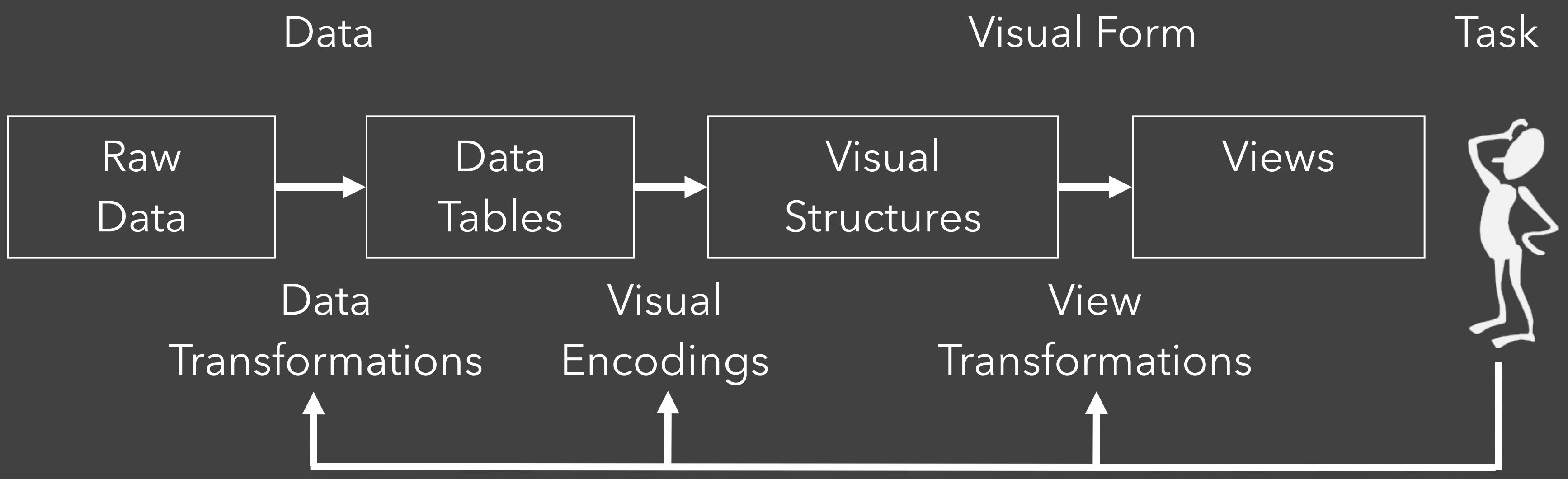
Canvas, OpenGL, Processing

Component Architectures

Prefuse, Flare, Improvise, VTK

Graphics APIs

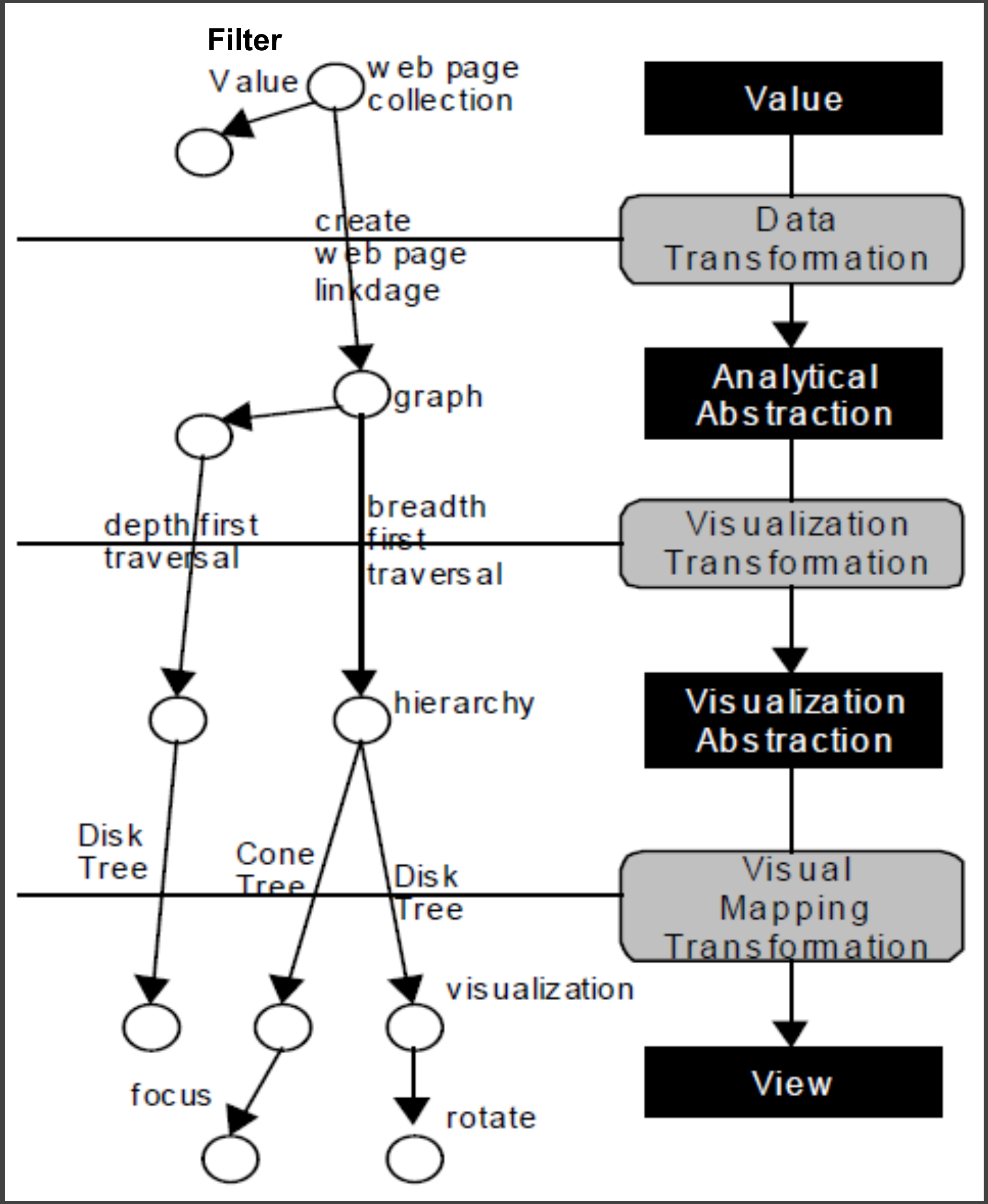
Canvas, OpenGL, Processing



Data
Visual Form
Task
Raw Data
Data Tables
Visual Structures
Views
Data Transformations
Visual Encodings
View Transformations

Data State Model

[Chi 98]



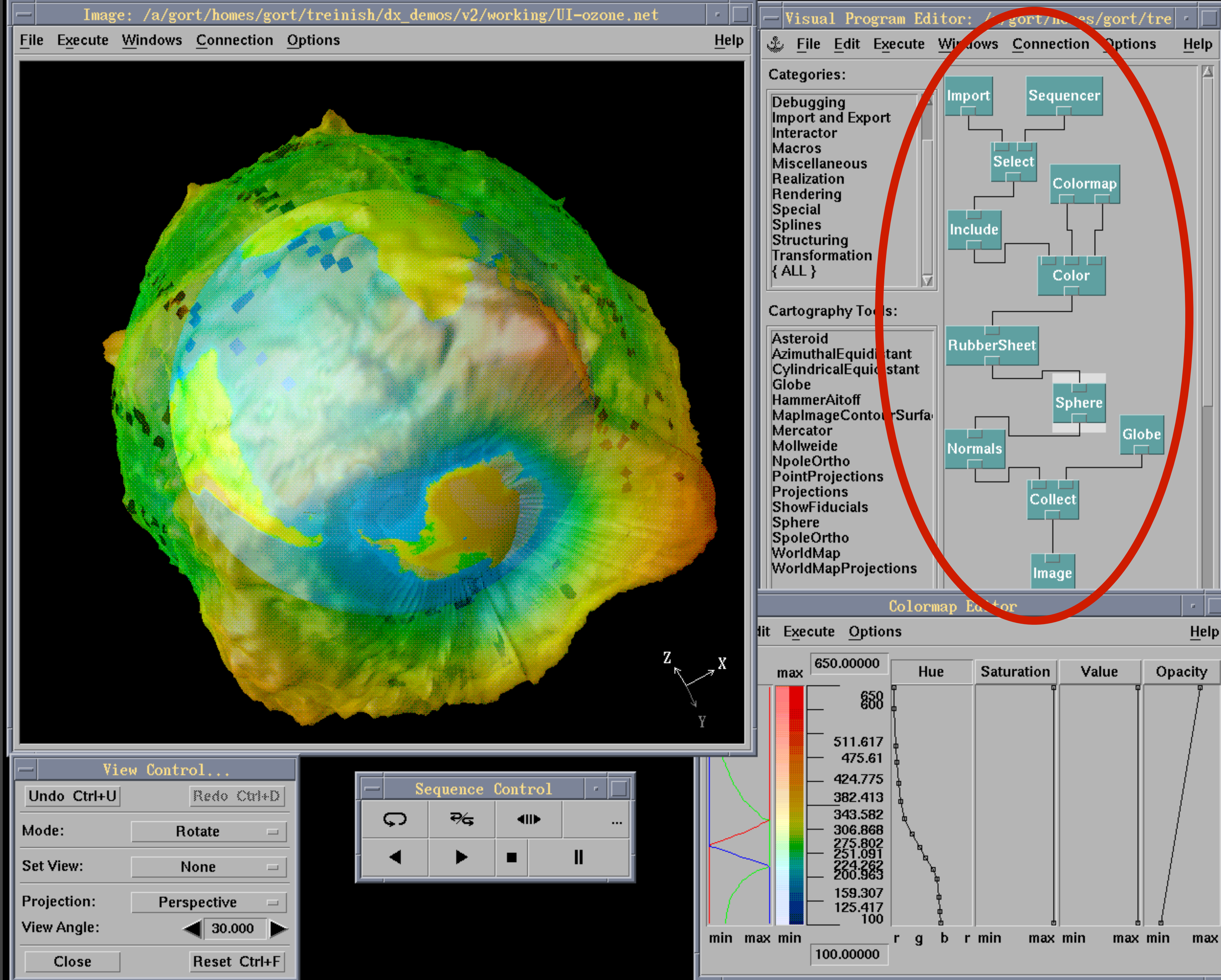
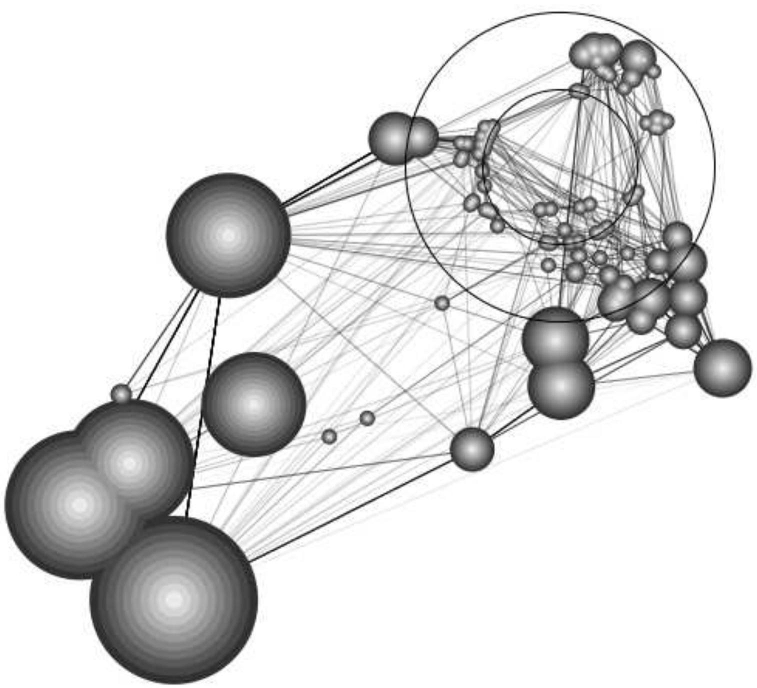


Image: /a/gort/homes/gort/treinish/dx_demos/v2/working/UI-ozone.net
File Execute Windows Connection Options Help
Z X Y
Visual Program Editor: /a/gort/homes/gort/tre
File Edit Execute Windows Connection Options Help
Categories:
Debugging
Import and Export
Interactor
Macros
Miscellaneous
Realization
Rendering
Special
Splines
Structuring
Transformation
{ ALL }
Cartography Tools:
Asteroid
AzimuthalEquidistant
CylindricalEquidistant
Globe
HammerAitoff
MapImageContourSurfa
Mercator
Mollweide
NpoleOrtho
PointProjections
Projections
ShowFiducials
Sphere
SpoleOrtho
WorldMap
WorldMapProjections
Import
Sequencer
Select
Colormap
Include
Color
RubberSheet
Sphere
Globe
Normals
Collect
Image
Colormap Editor
Edit Execute Options Help
max
650.00000
Hue
Saturation
Value
Opacity
650
600
511.617
475.61
424.775
382.413
343.582
306.868
275.802
251.091
224.262
200.963
159.307
125.417
100
min max min
r g b r min max min max min max
100.00000
View Control...
Undo Ctrl+U
Redo Ctrl+D
Mode: Rotate
Set View: None
Projection: Perspective
View Angle: 30.000
Close
Reset Ctrl+F
Sequence Control

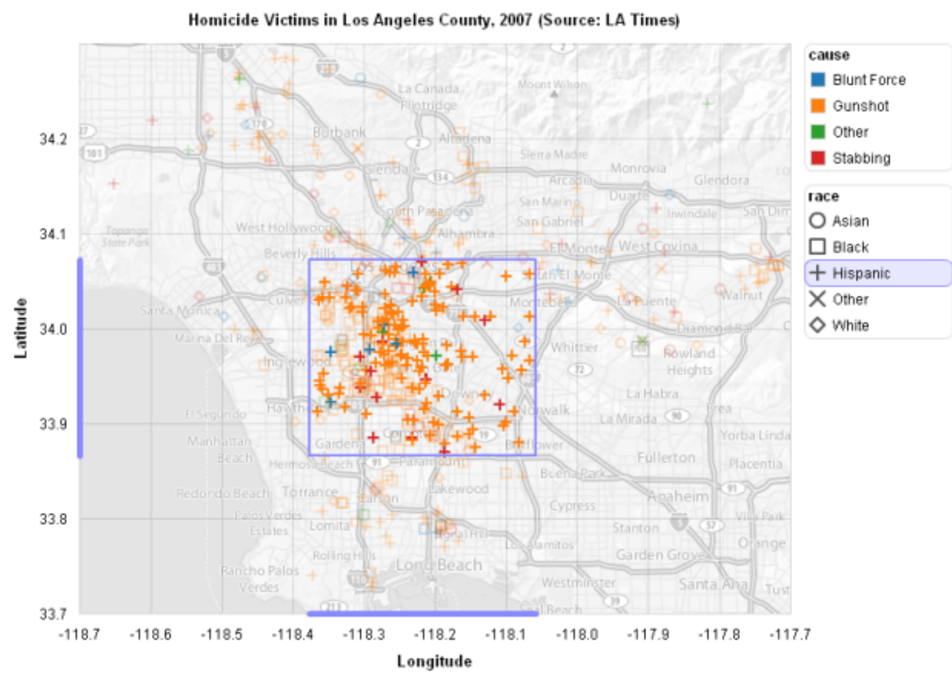
Prefuse & Flare

Operator-based toolkits for visualization design

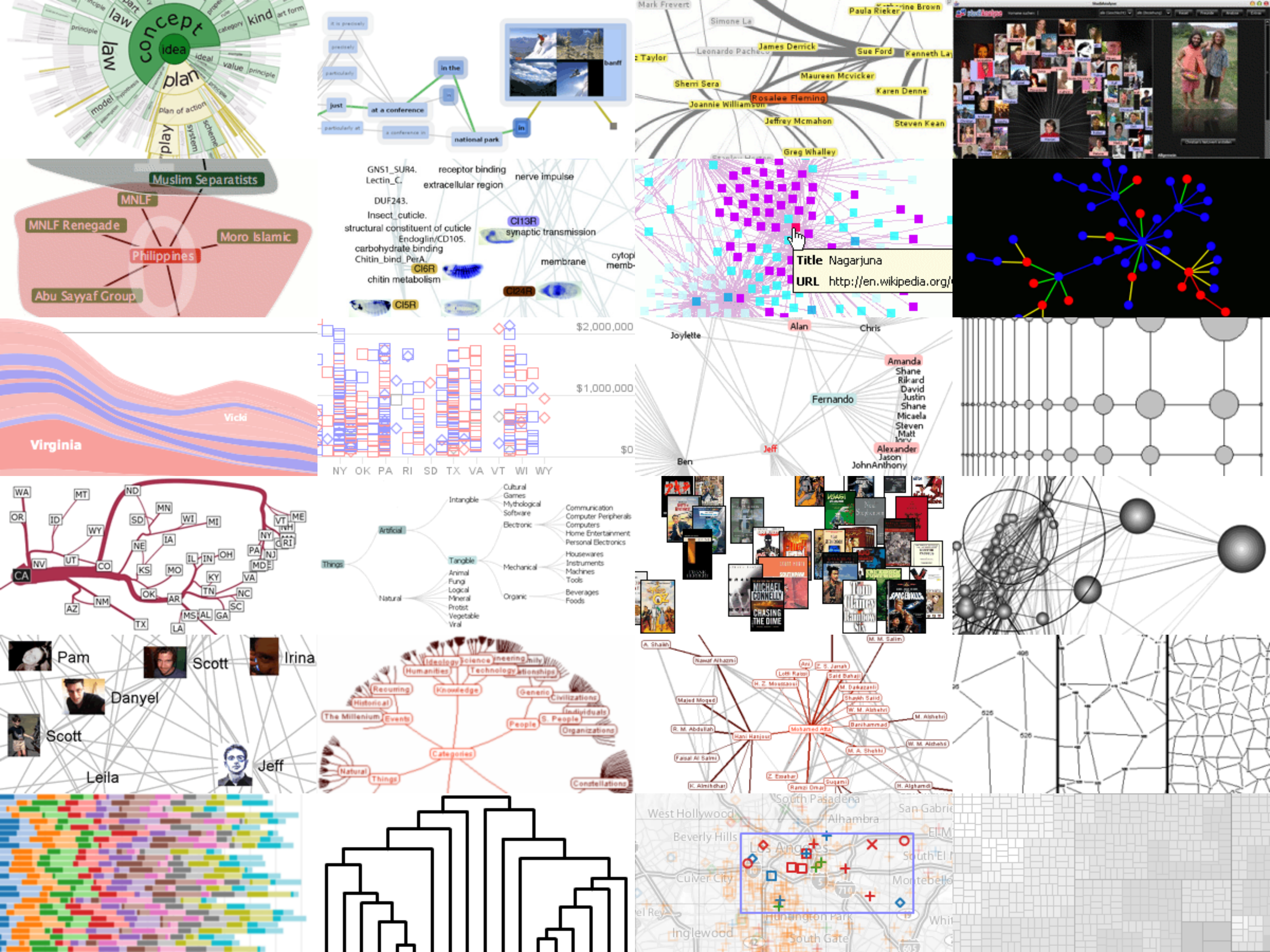
Vis = (Input Data -> Visual Objects) + Operators



Prefuse (http://prefuse.org)



Flare (http://flare.prefuse.org)



concept
idea
law
plan
kind
ideal
value
principle
plan of action
play
system
model
in the
just
at a conference
national park
banff
Mark Frevert
Simone La
Paula Rieker
James Derrick
Sue Ford
Kenneth Lay
Sherri Sera
Maureen Mcvicker
Karen Denne
Rosalee Fleming
Joannie Williamson
Jeffrey Mcmahon
Steven Kean
Greg Whalley
Muslim Separatists
MNLF
MNLF Renegade
Moro Islamic
Philippines
Abu Sayyaf Group
GNS1_SUR4.
Lectin_C.
receptor binding
extracellular region
nerve impulse
DUF243.
Insect_cuticle.
structural constituent of cuticle
Endoglin/CD105.
carbohydrate binding
Chitin_bind_PerA.
chitin metabolism
CI13R
synaptic transmission
CI6R
membrane
CI5R
CI24R
Title Nagarjuna
URL http://en.wikipedia.org/
Vicki
Virginia
$2,000,000
$1,000,000
$0
NY OK PA RI SD TX VA VT WI WY
Joylette
Alan
Chris
Amanda
Shane
Rikard
David
Justin
Shane
Micaela
Steven
Matt
Fernando
Jeff
Alexander
Jason
JohnAnthony
Ben
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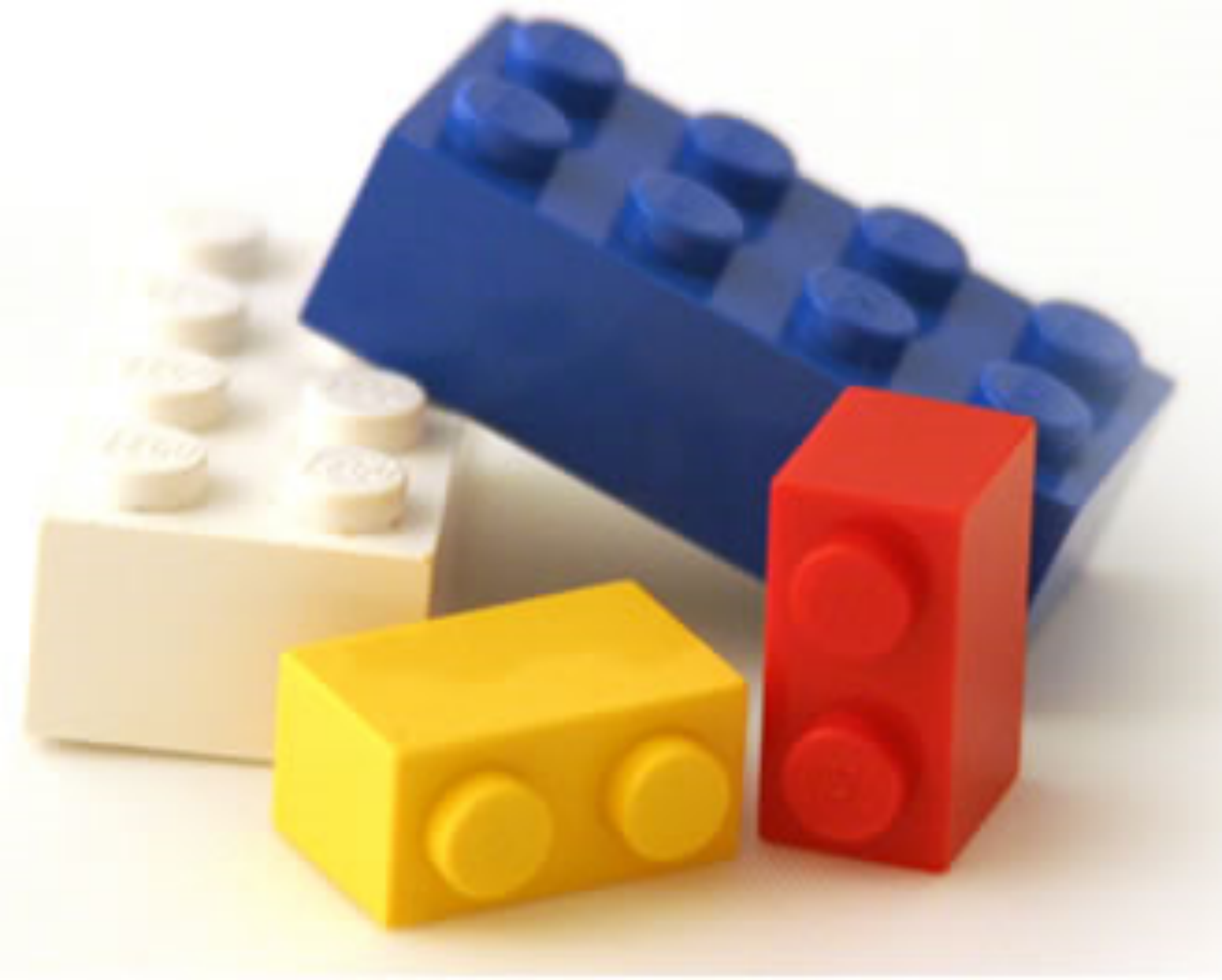
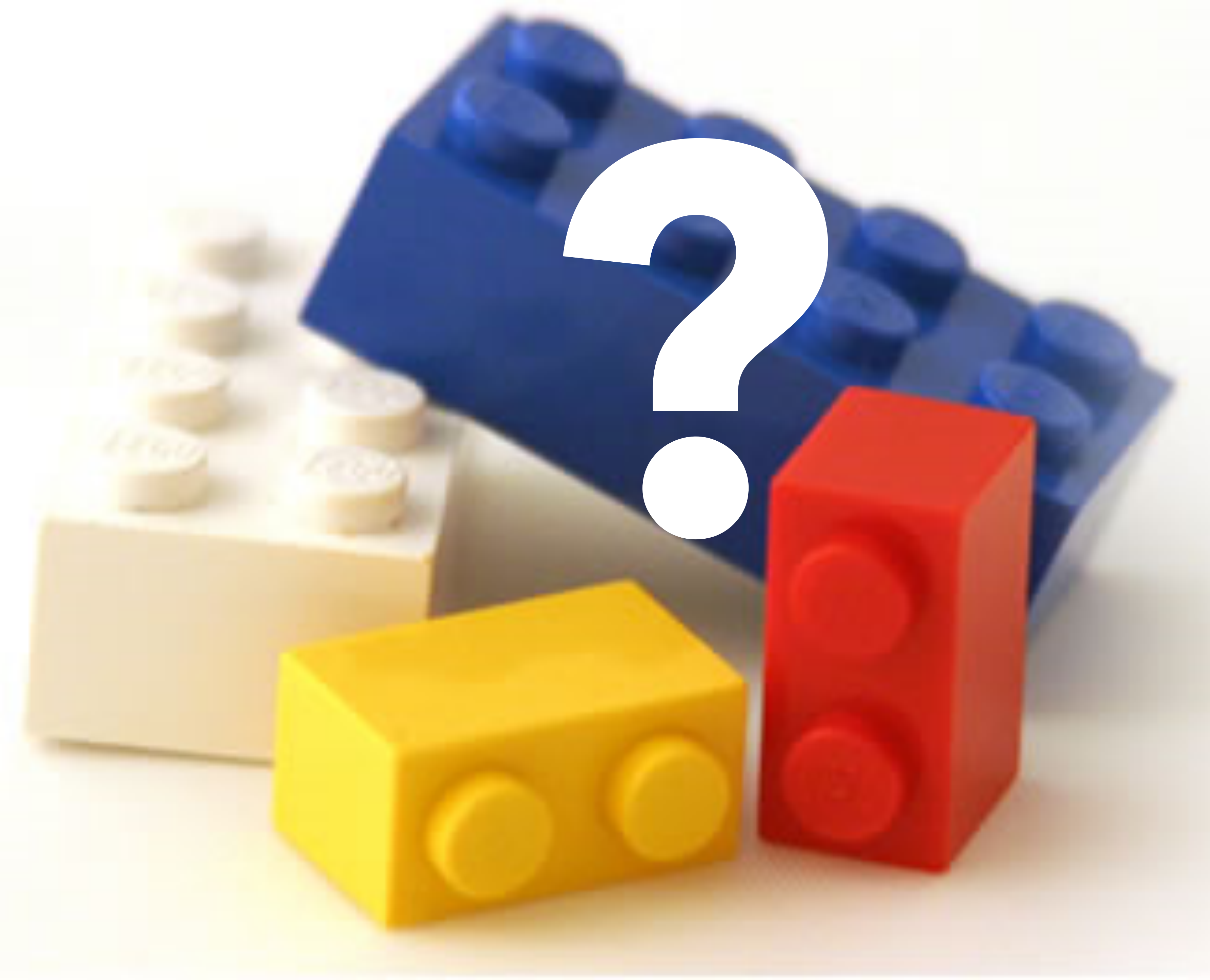
MD
VT
NH
ME
RI
Things
Artificial
Intangible
Cultural
Games
Mythological
Software
Electronic
Communication
Computer Peripherals
Computers
Home Entertainment
Personal Electronics
Tangible
Mechanical
Housewares
Instruments
Machines
Tools
Natural
Animal
Fungi
Logical
Mineral
Protist
Vegetable
Viral
Organic
Beverages
Foods
Pam
Scott
Irina
Danyel
Scott
Jeff
Leila
Ideology
Science
Humanities
Technology
Knowledge
Historical
The Millenium
Events
Generic
Civilizations
People
Organizations
Categories
Natural
Things
Constellations
West Hollywood
South Pasadena
Alhambra
San Gabriel
Beverly Hills
Los Angeles
Culver City
Montebello
Huntington Park
Inglewood
South Gate





Component Architectures

Prefuse, Flare, Improvise, VTK

Graphics APIs

Canvas, OpenGL, Processing

Chart Typologies

Excel, Google Charts

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Chart Typologies

Data Sets : State Quick Facts

Uploaded By: zinggoat
Created at: Friday May 18, 3:08 PM
Data Source: US Census Bureau
Description:
Tags: people census

view as text   edit data set

	People QuickFacts	Population 2005 estimate	Population percent change April 1 2000 to July 1 2005	Population 2000	Population percent change 1990 to 2000	Persons under 5 years old percent 2004	Persons under 18 years old percent 2004	Persons 65 years old and over percent 2004
1	Alabama	4557808	0.03	4447100	0.1	0.07	0.24	0.13
2	Alaska	663661	0.06	626932	0.14	0.08	0.29	0.06
3	Arizona	5939292	0.16	5130632	0.4	0.08	0.27	0.13
4	Arkansas	2779154	0.04	2673400	0.14	0.07	0.25	0.14
5	California	36132147	0.07	33871648	0.14	0.07	0.27	0.11
6	Colorado	4665177	0.08	4301261	0.31	0.07	0.26	0.1
7	Connecticut	3510297	0.03	3405565	0.04	0.06	0.24	0.14
8	Delaware	843524	0.08	783600	0.18	0.07	0.23	0.13
9	Florida	17789864	0.11	15982378	0.24	0.06	0.23	0.17
10	Georgia	9072576	0.11	8186453	0.26	0.08	0.26	0.1
11	Hawaii	1275194	0.05	1211537	0.09	0.07	0.24	0.14
12	Idaho	1429096	0.1	1293953	0.29	0.07	0.27	0.11
13	Illinois	12763371	0.03	12419293	0.09	0.07	0.26	0.12

Choosing a visualization type for State Quick Facts

Analyze a text

Tag Cloud

How are you using your words? This enhanced tag cloud will show you the words popularity in the given set of text.

Learn more

Wordle

Wordle is a toy for generating "word clouds" from text that you provide. The clouds give greater prominence to words that appear more frequently in the source text.

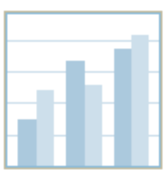
Learn more

Word Tree

See a branching view of how a word or phrase is used in a text. Navigate the text by zooming and clicking.

Learn more

Compare a set of values



Bar Chart

How do the items in your data set stack up? A bar chart is a simple and recognizable way to compare values. You can display several sets of bars for multivariate comparisons.

Learn more

Block Histogram

This versatile chart lets you get a quick sense of how a single set of data is distributed. Each item in the data is an individually identifiable block.

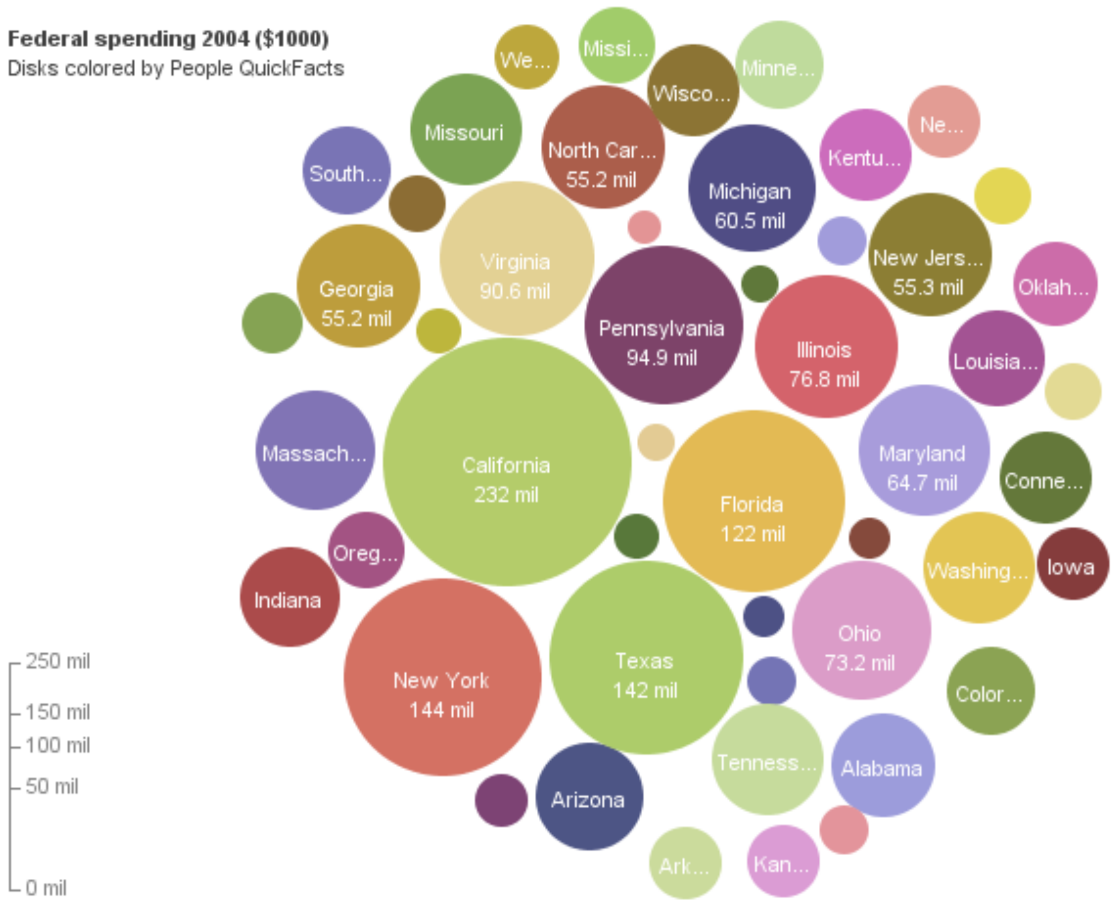
Learn more

Visualizations : Federal Spending by State, 2004

Creator: Anonymous
Tags: census people

People QuickFac...
Click to select,
Ctrl-Click: multiple
Shift-Click: range

- Alabama
- Alaska
- Arizona
- Arkansas
- California
- Colorado
- Connecticut
- Delaware
- Florida
- Georgia
- Hawaii
- Idaho
- Illinois
- Indiana
- Iowa
- Kansas
- Kentucky
- Louisiana
- Maine
- Maryland



Search>>

To highlight or find totals click or ctrl-click.

Bubble Size: Federal spending 2004 ($1000) | Label: People QuickFacts | Color: People QuickFacts

- Retail sales per capita 2002
- Minority-owned firms percent of total 1997
- Women-owned firms percent of total 1997
- Housing units authorized by building permits 2004
- Federal spending 2004 ($1000)
- Land area 2000 (square miles)
- Persons per square mile 2000
- FIPS Code

Data file ... Census Bureau

This data set has not yet been rated

full image

rate this

MAD LIBS®

MY MUSIC LESSON

Every Wednesday, when I get home from school, I have a piano lesson. My teacher is a very strict house (NOUN). Her name is Hillary Clinton (CELEBRITY (FEMALE)). Our piano is a Steinway Concert tree (NOUN) and it has 88 cups (PLURAL NOUN). It also has a soft pedal and a/an Smily (ADJECTIVE) pedal. When I have a lesson, I sit down on the piano AIBERTO (NOUN) and play for 16 Minuts (PERIOD OF TIME). I do scales to exercise my cats (PLURAL NOUN), and then I usually play a minuet by Johann Sebastian washington (CELEBRITY (LAST NAME)). Teacher says I am a natural Hanted House (NOUN) and have a good musical leg (PART OF THE BODY). Perhaps when I get better I will become a concert vet (PROFESSION) and give a recital at Carnegie hospital (TYPE OF BUILDING).

[M]ost charting packages channel user requests into a **rigid array of chart types**. To atone for this lack of flexibility, they offer a kit of post-creation editing tools to return the image to what the user originally envisioned. **They give the user an impression of having explored data rather than the experience**.

Leland Wilkinson
The Grammar of Graphics, 1999

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Excel, Many Eyes, Google Charts

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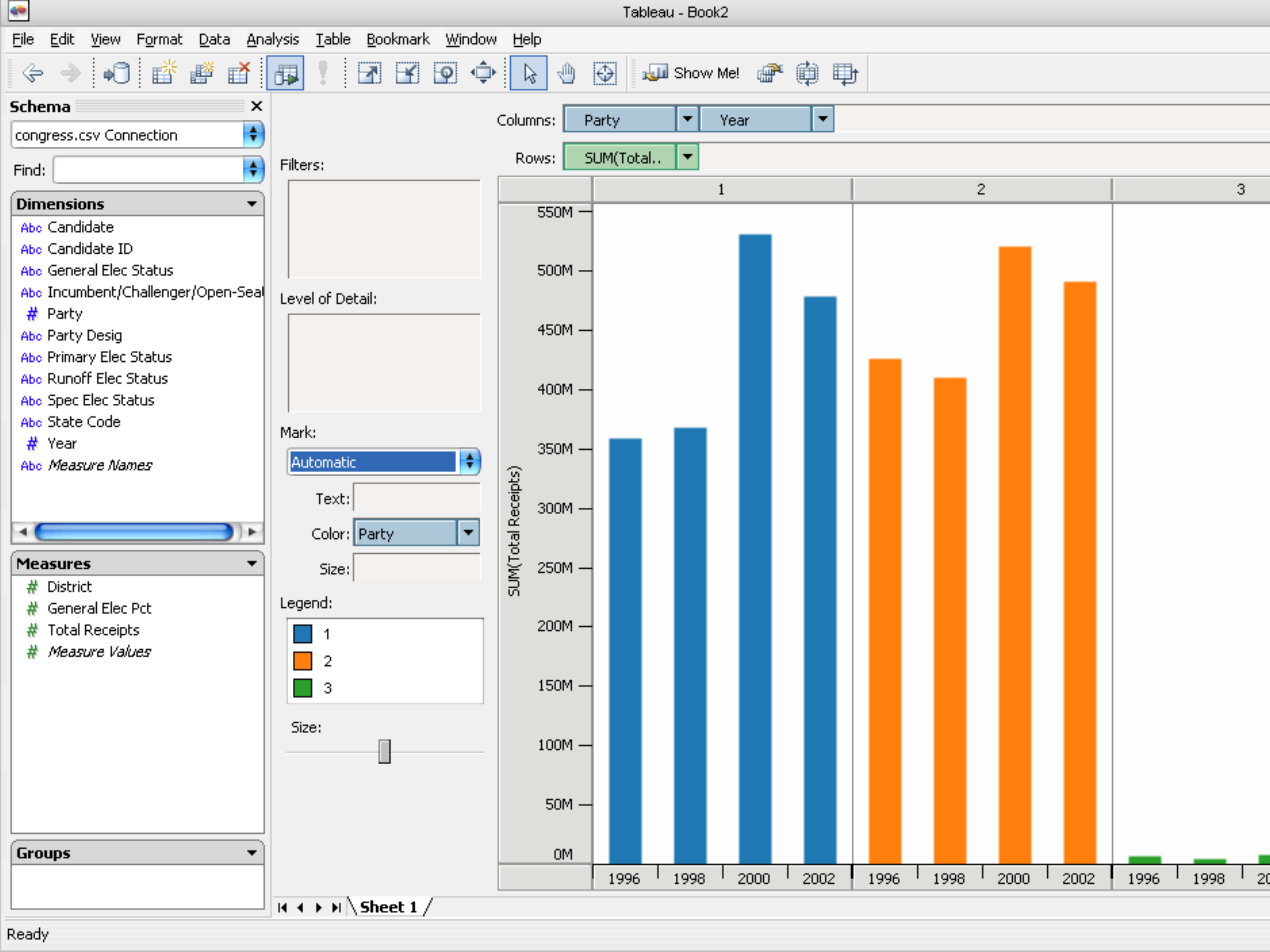
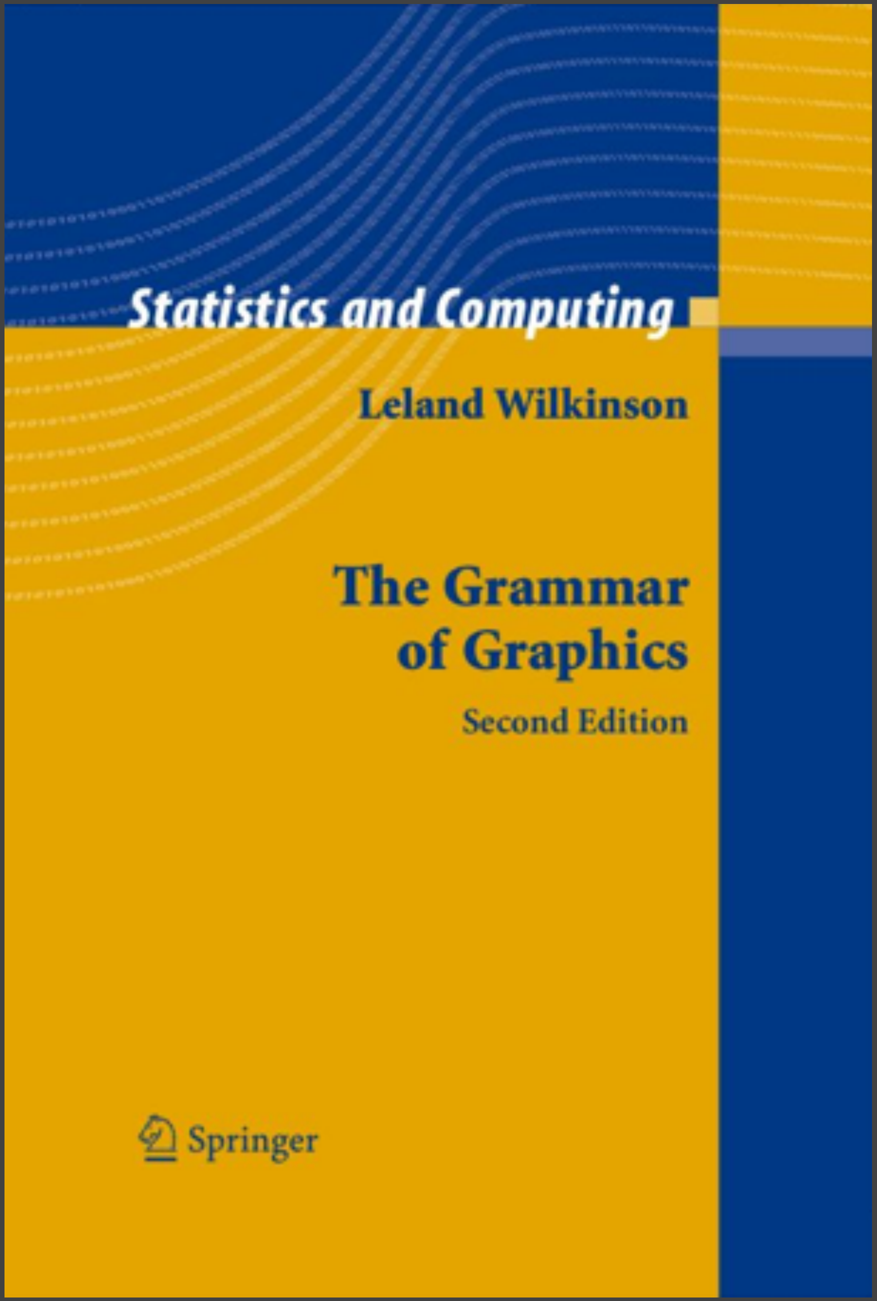
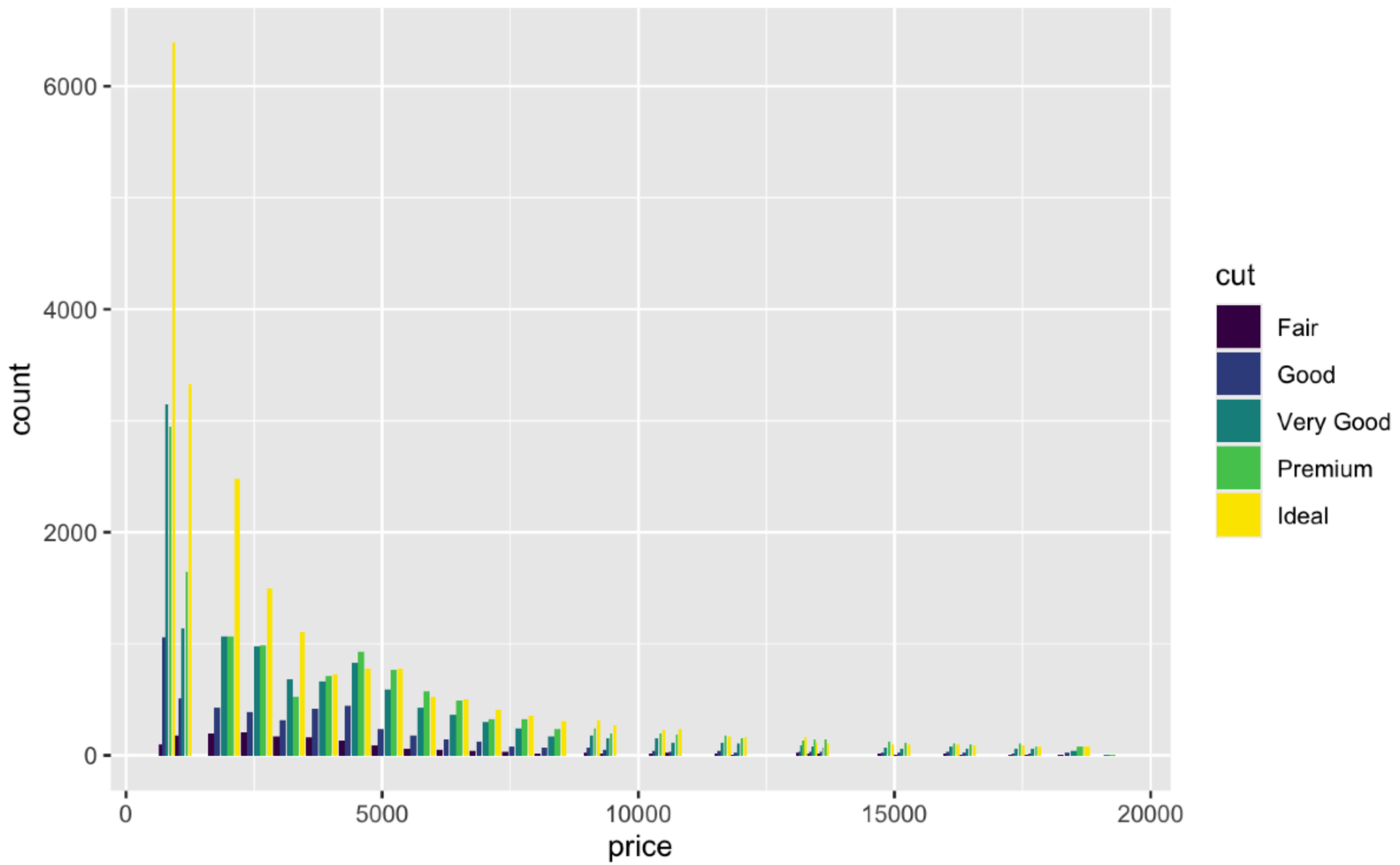


Tableau - Book2
File Edit View Format Data Analysis Table Bookmark Window Help
Show Me!
Schema
congress.csv Connection
Find:
Dimensions
Abc Candidate
Abc Candidate ID
Abc General Elec Status
Abc Incumbent/Challenger/Open-Seat
Party
Abc Party Desig
Abc Primary Elec Status
Abc Runoff Elec Status
Abc Spec Elec Status
Abc State Code
Year
Abc Measure Names
Measures
District
General Elec Pct
Total Receipts
Measure Values
Groups
Filters:
Level of Detail:
Mark:
Automatic
Text:
Color: Party
Size:
Legend:
1
2
3
Size:
Columns: Party Year
Rows: SUM(Total..
1
2
3
550M
500M
450M
400M
350M
300M
250M
200M
150M
100M
50M
0M
SUM(Total Receipts)
1996
1998
2000
2002
1996
1998
2000
2002
1996
1998
Sheet 1
Ready


Statistics and Computing
Leland Wilkinson
The Grammar of Graphics
Second Edition
Springer

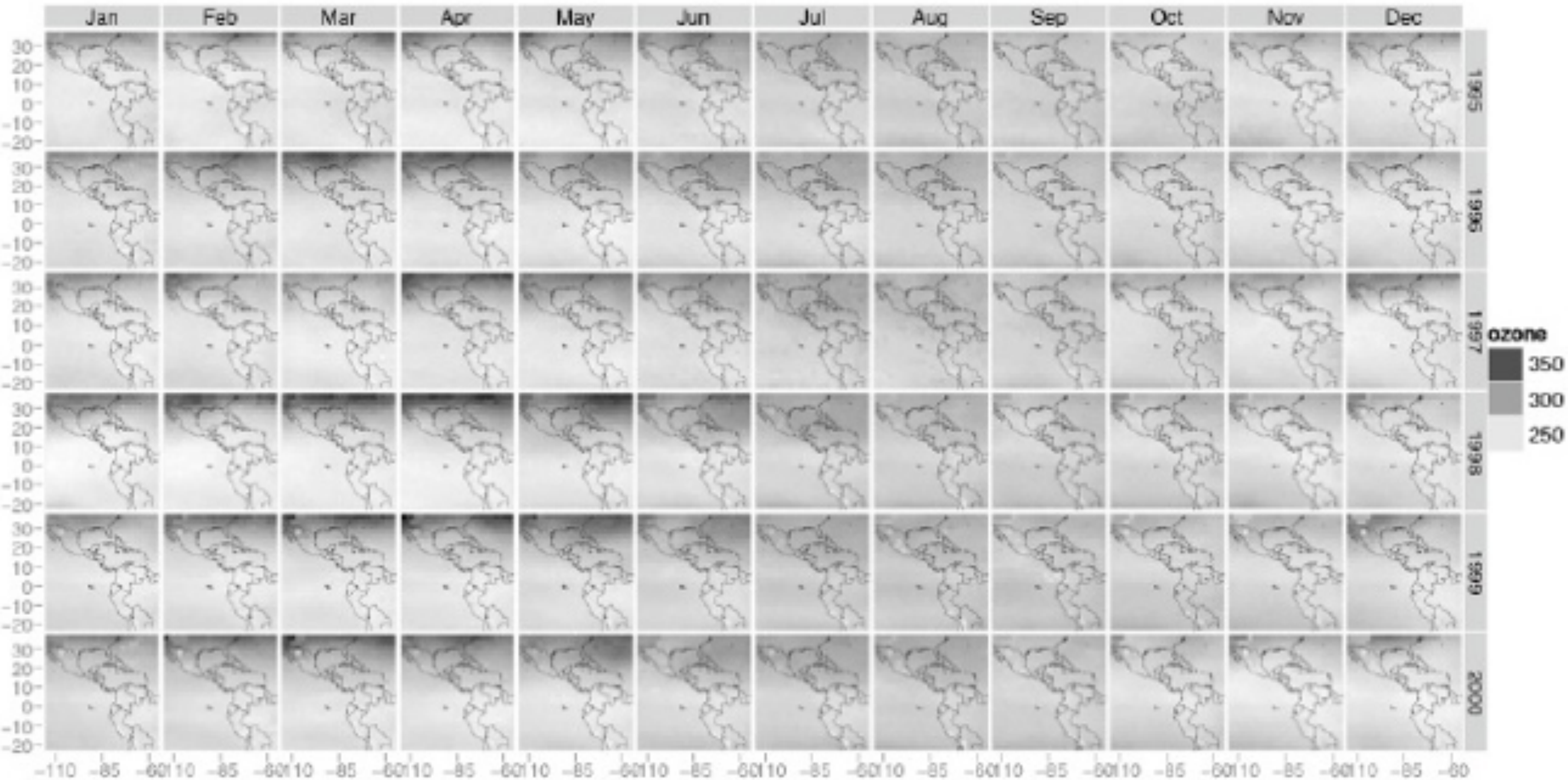
```
ggplot(diamonds, aes(x=price, fill=cut))
+ geom_bar(position="dodge")
```

ggplot2



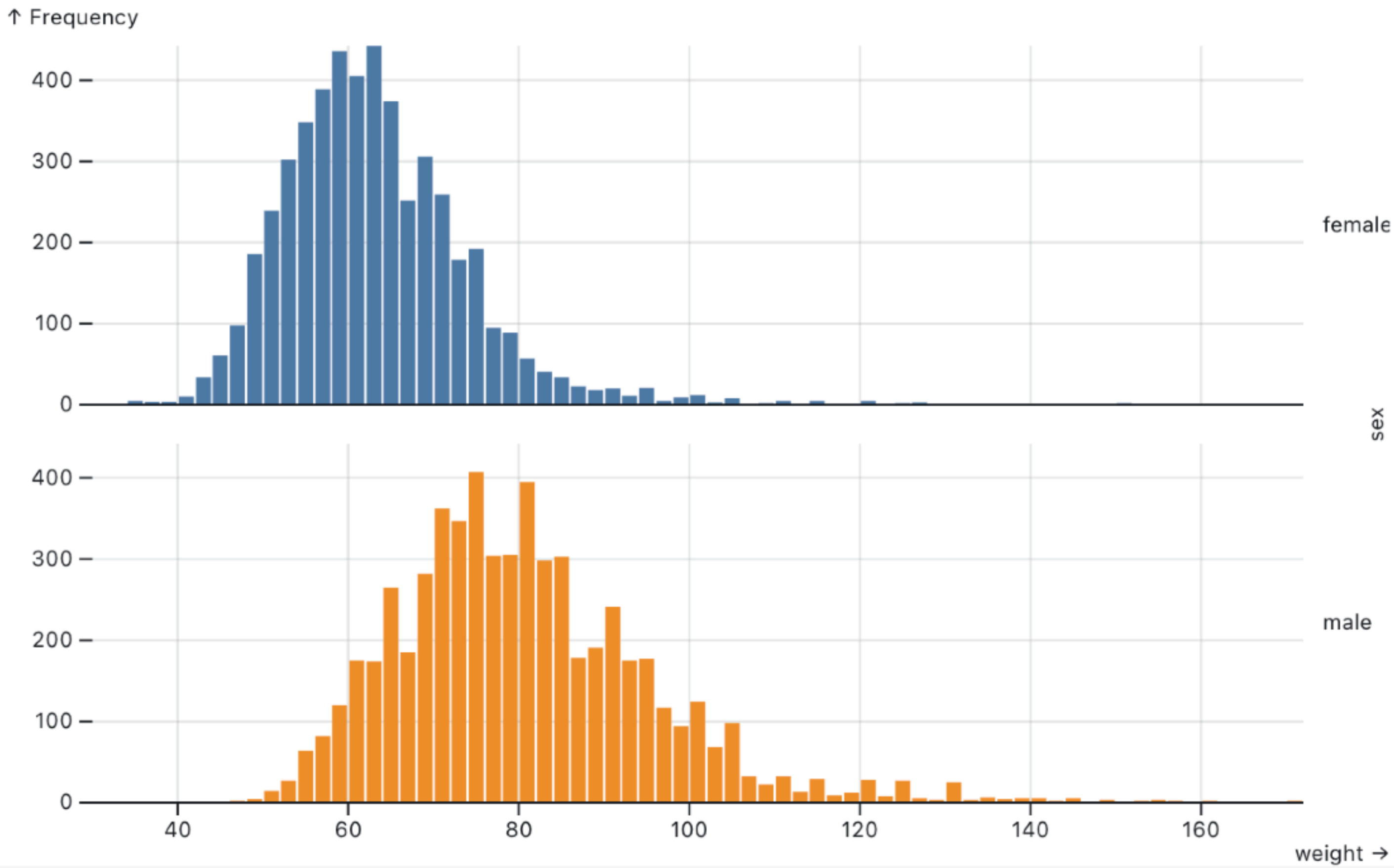

```
ggplot(diamonds, aes(x=price, fill=cut))
+ geom_bar(position="dodge")
```

ggplot2




```
qplot(long, lat, data = expo, geom = "tile", fill = ozone,
  facets = year ~ month) +
scale_fill_gradient(low = "white", high = "black") + map
```

ggplot2




```
Plot.plot({
  grid: true,
  facet: {
    data: athletes,
    y: "sex"
  },
  marks: [
    Plot.rectY(athletes, Plot.binX({y: "count"}, {x: "weight", fill: "sex"})),
    Plot.ruleY([0])
  ]
})
```

Observable Plot

Chart Typologies

Excel, Many Eyes, Google Charts

Visual Analysis Grammars

VizQL, ggplot2

Component Architectures

Prefuse, Flare, Improvise, VTK

Graphics APIs

Canvas, OpenGL, Processing

Ease-of-Use

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Excel, Many Eyes, Google Charts

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Ease-of-Use

Expressiveness

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VizQL, ggplot2

?

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Prefuse, Flare, Improvise, VTK

Graphics APIs

Canvas, OpenGL, Processing

Ease-of-Use

Expressiveness

Chart Typologies

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Visual Analysis Grammars

VizQL, ggplot2

Visualization Grammars

Protovis, D3.js

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Prefuse, Flare, Improvise, VTK

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Canvas, OpenGL, Processing

Protovis & D3

Today's first task is not to invent wholly new [*graphical*] techniques, though these are needed. Rather we need most vitally to recognize and reorganize the **essential of old techniques**, to **make easy their assembly in new ways**, and to **modify their external appearances to fit the new opportunities**.

J. W. Tukey, M. B. Wilk

Data Analysis & Statistics, 1965

Visualization Grammar

Visualization Grammar

Data Input data to visualize

Visualization Grammar

Data	Input data to visualize
Transforms	Group, aggregate, stats, layout

Visualization Grammar

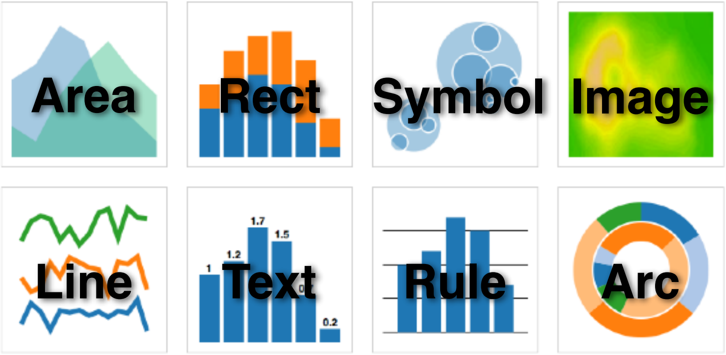
Data	Input data to visualize
Transforms	Group, aggregate, stats, layout
Scales	Map data values to visual values

Visualization Grammar

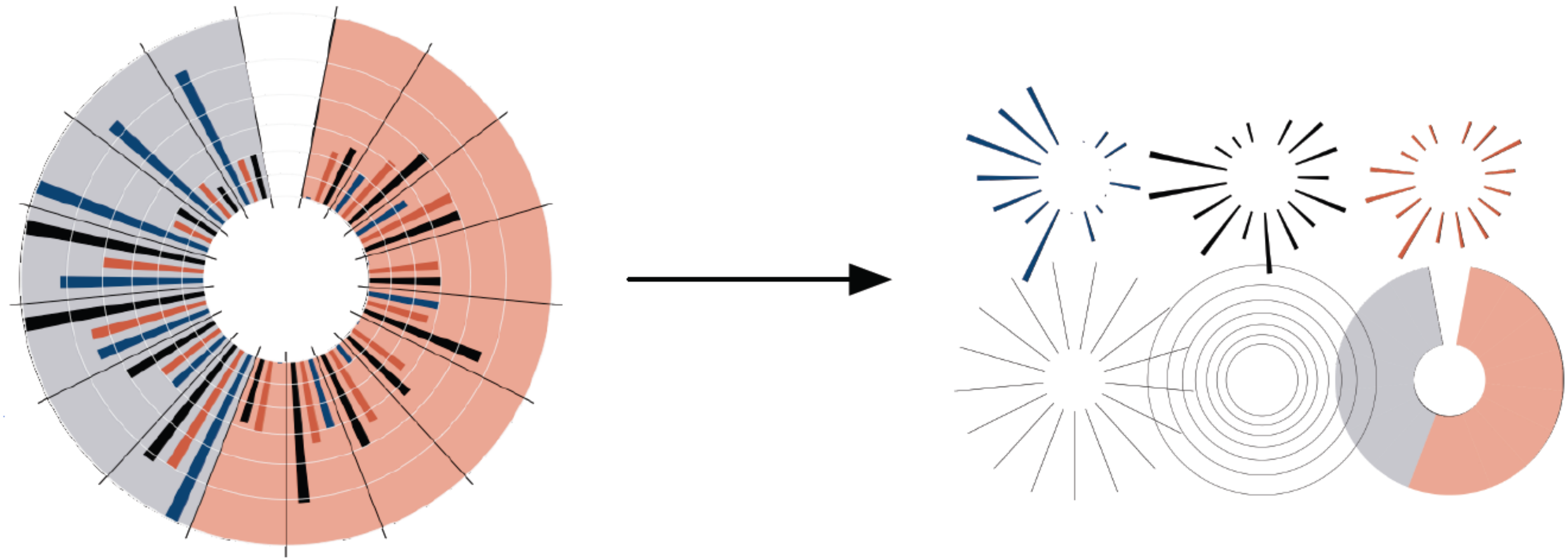
Data	Input data to visualize
Transforms	Group, aggregate, stats, layout
Scales	Map data values to visual values
Guides	Axes & legends visualize scales

Visualization Grammar

Data	Input data to visualize
Transforms	Group, aggregate, stats, layout
Scales	Map data values to visual values
Guides	Axes & legends visualize scales
Marks	Data-representative graphics

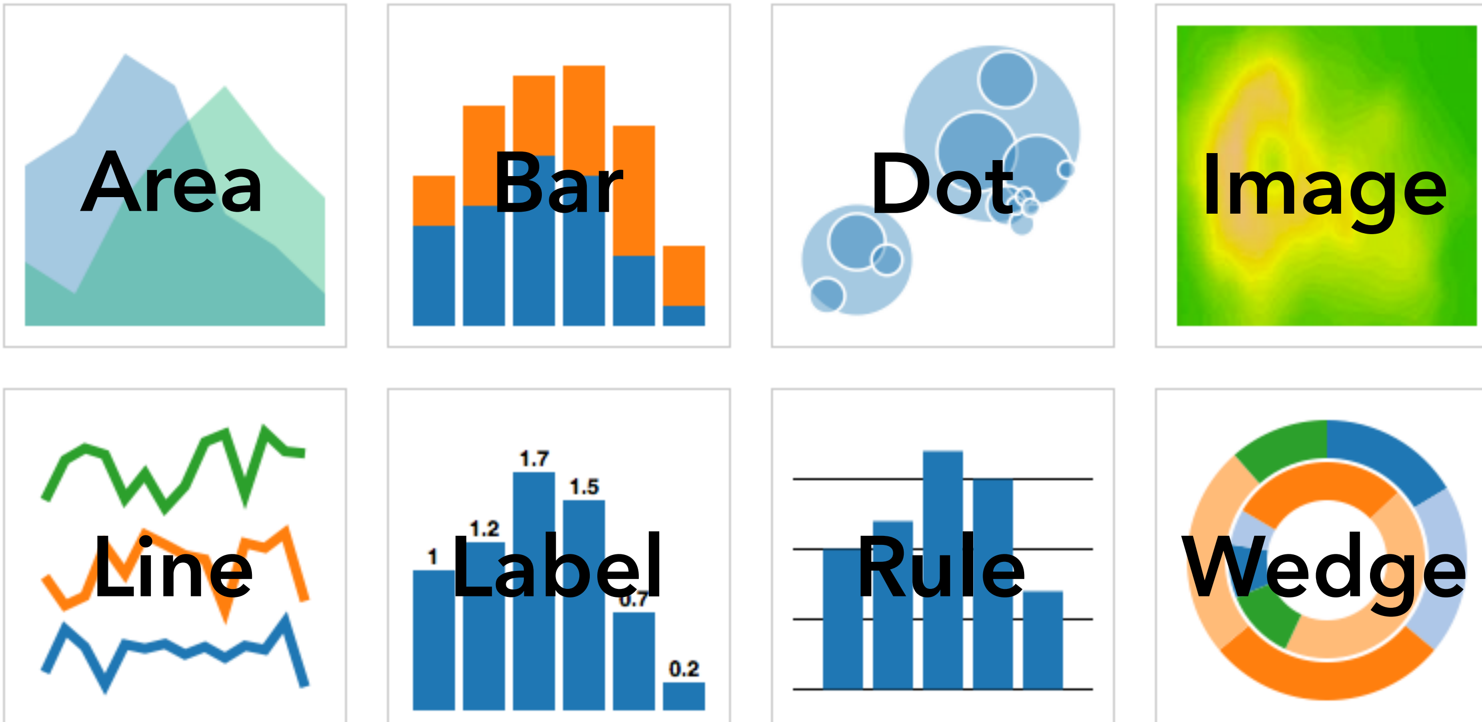


Protovis: A Grammar for Visualization



A graphic is a composition of data-representative marks.

with **Mike Bostock** & **Vadim Ogievetsky**



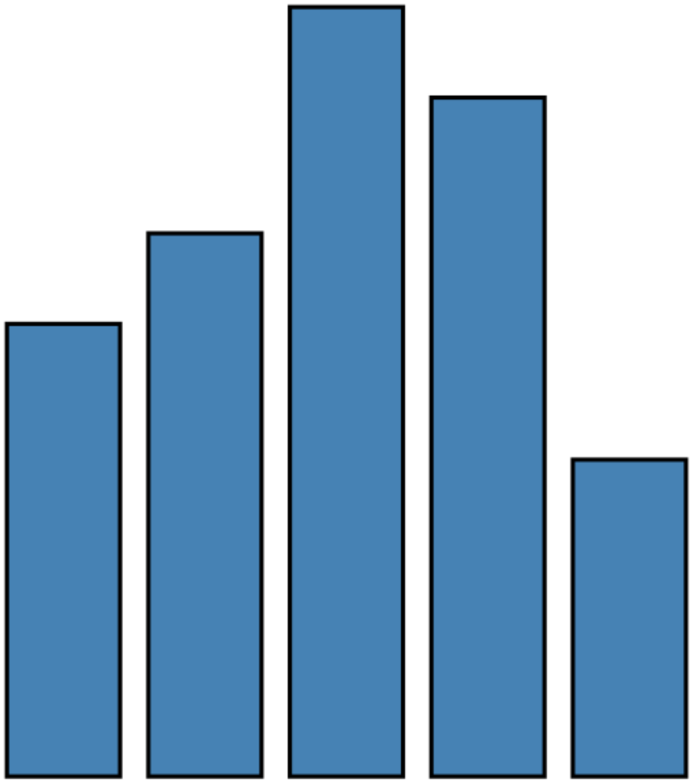
MARKS: Protovis graphical primitives

MARK $\lambda : \boldsymbol{D} \rightarrow \boldsymbol{R}$

data	λ
visible	λ
left	λ
bottom	λ
width	λ
height	λ
fillStyle	λ
strokeStyle	λ
lineWidth	λ
...	λ

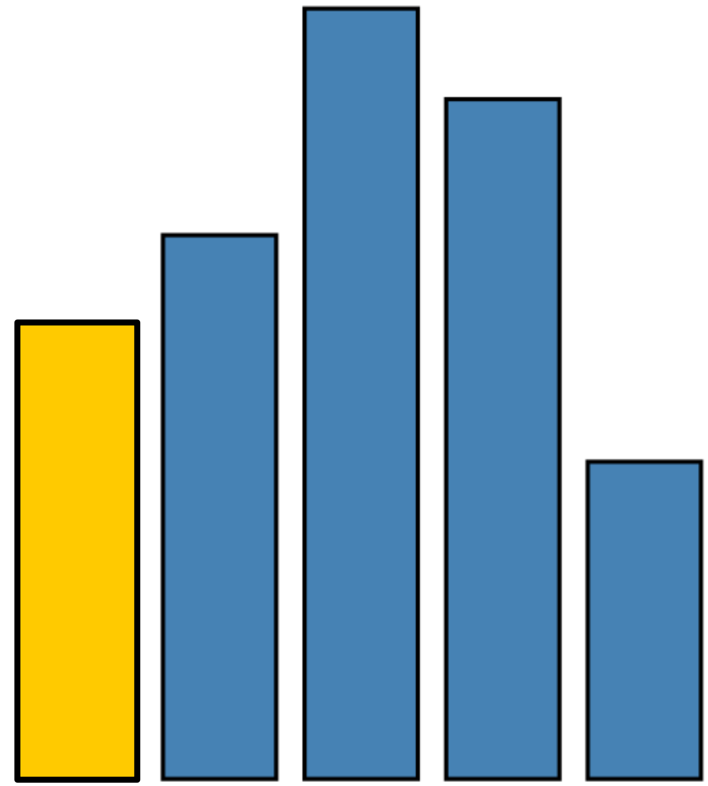
RECT $\lambda : D \to R$

data	1	1.2	1.7	1.5	0.7
visible	true				
left	λ: index * 25				
bottom	0				
width	20				
height	λ: datum * 80				
fillStyle	blue				
strokeStyle	black				
lineWidth	1.5				
...	...				



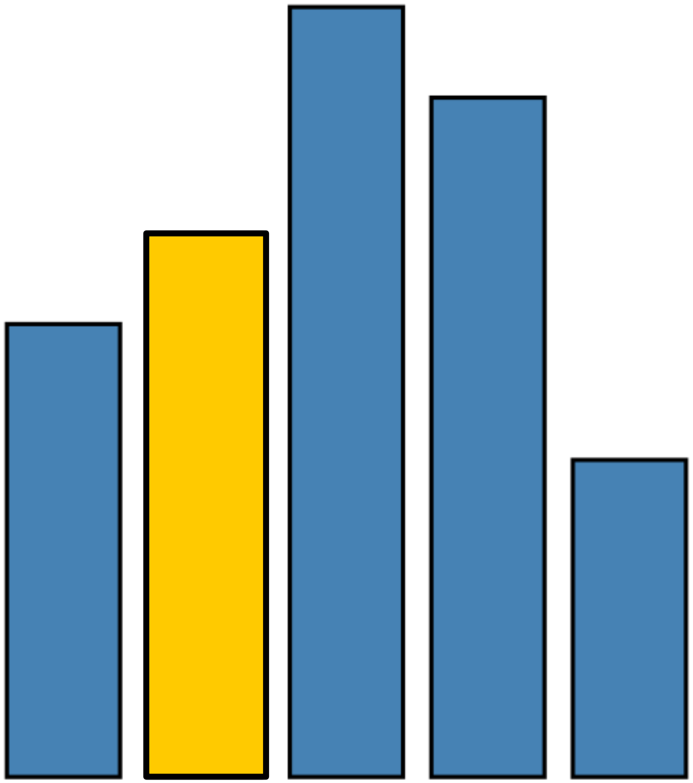
RECT $\lambda : \boldsymbol{D} \rightarrow \boldsymbol{R}$

data	1	1.2	1.7	1.5	0.7
visible	true				
left	0 * 25				
bottom	0				
width	20				
height	1 * 80				
fillStyle	blue				
strokeStyle	black				
lineWidth	1.5				
...	...				



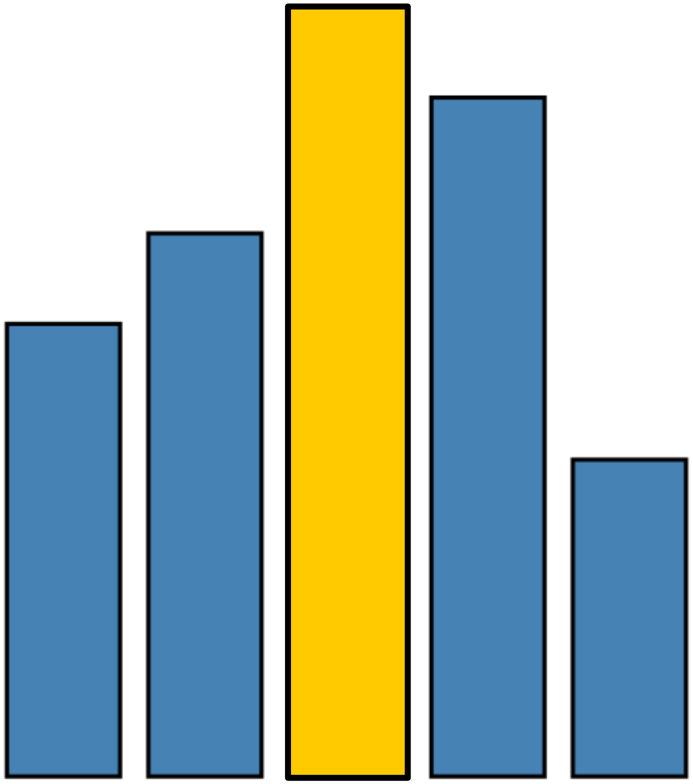
RECT $\lambda : \boldsymbol{D} \rightarrow \boldsymbol{R}$

data	1	1.2	1.7	1.5	0.7
visible	true				
left	1 * 25				
bottom	0				
width	20				
height	1.2 * 80				
fillStyle	blue				
strokeStyle	black				
lineWidth	1.5				
...	...				



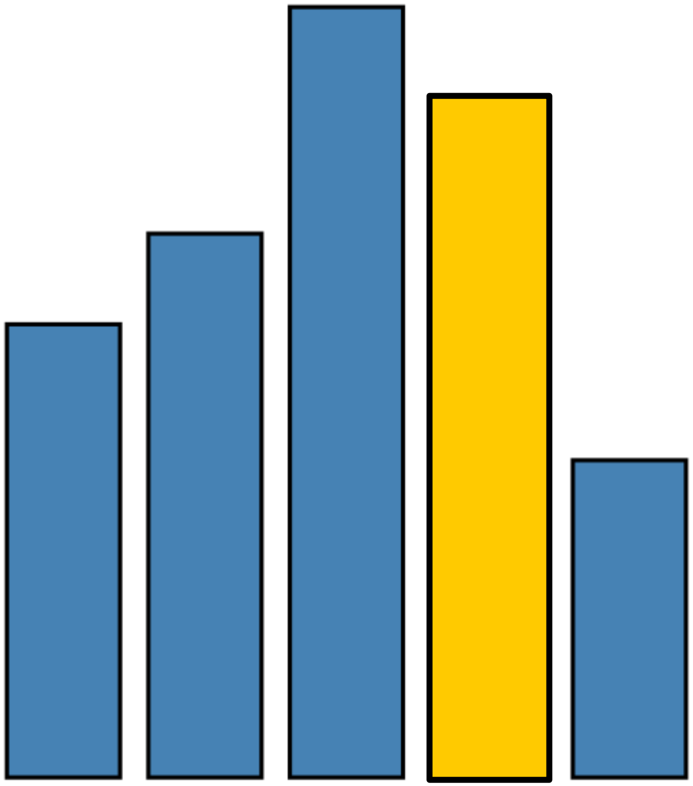
RECT $\lambda : \boldsymbol{D} \rightarrow \boldsymbol{R}$

data	1	1.2	1.7	1.5	0.7
visible	true				
left	2 * 25				
bottom	0				
width	20				
height	1.7 * 80				
fillStyle	blue				
strokeStyle	black				
lineWidth	1.5				
...	...				



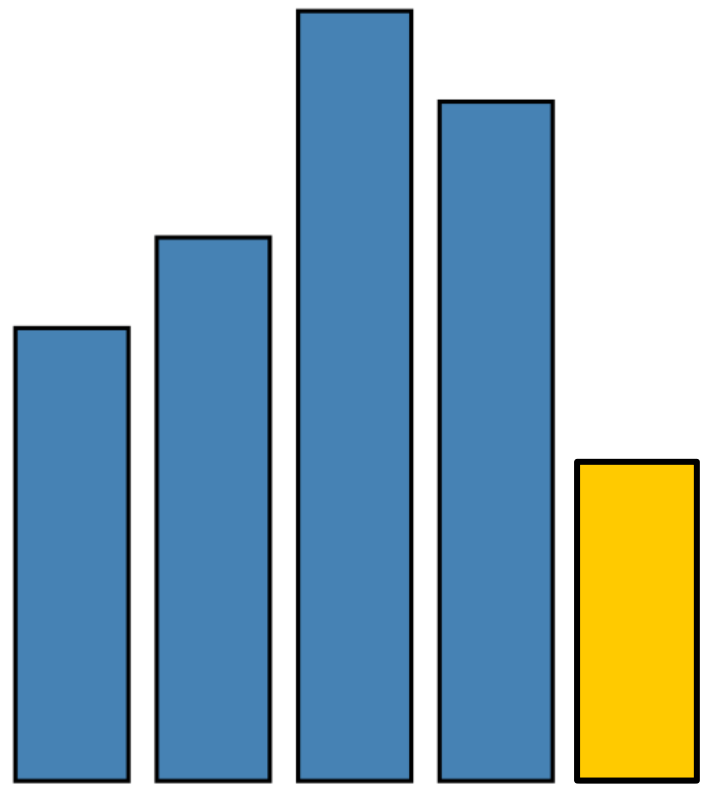
RECT $\lambda : D \rightarrow R$

data	1	1.2	1.7	1.5	0.7
visible	true				
left	3 * 25				
bottom	0				
width	20				
height	1.5 * 80				
fillStyle	blue				
strokeStyle	black				
lineWidth	1.5				
...	...				



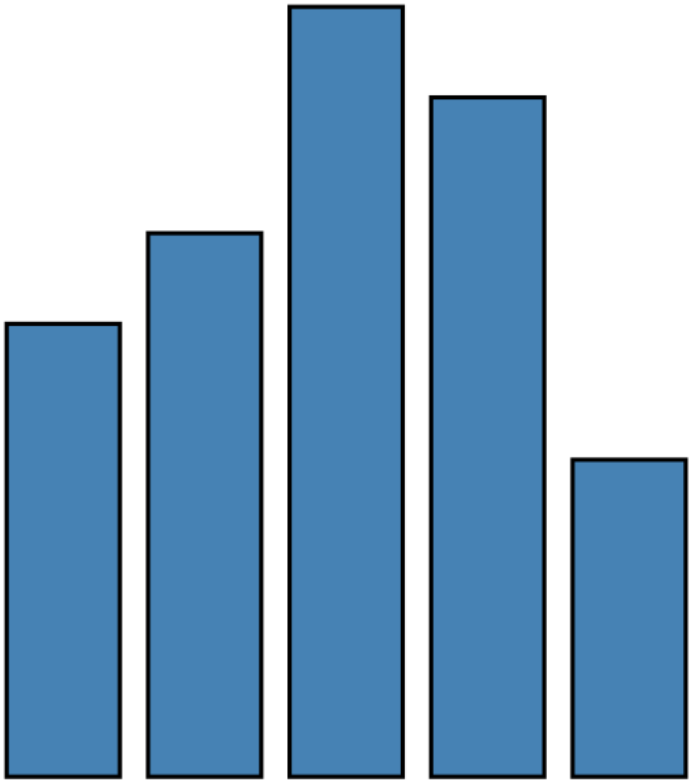
RECT $\lambda : \boldsymbol{D} \rightarrow \boldsymbol{R}$

data	1	1.2	1.7	1.5	0.7
visible	true				
left	4 * 25				
bottom	0				
width	20				
height	0.7 * 80				
fillStyle	blue				
strokeStyle	black				
lineWidth	1.5				
...	...				

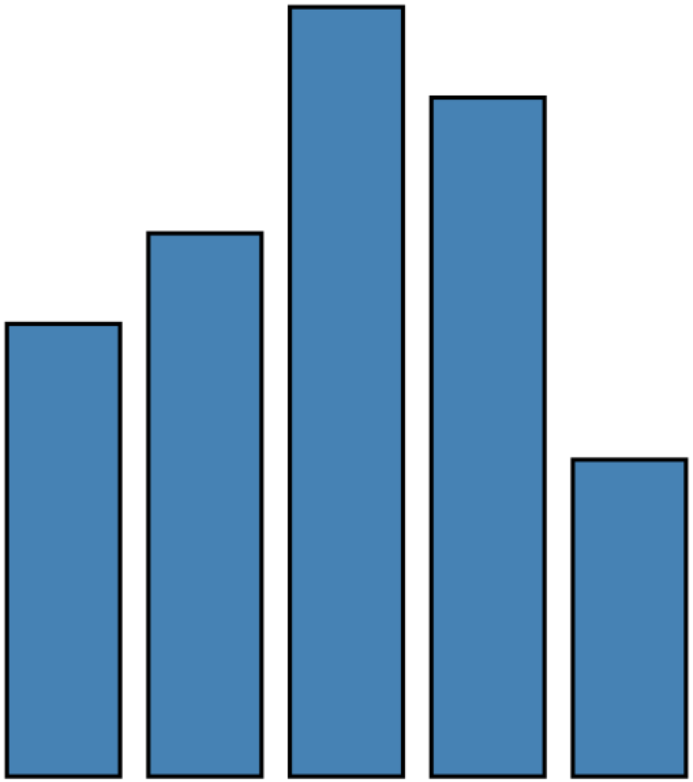


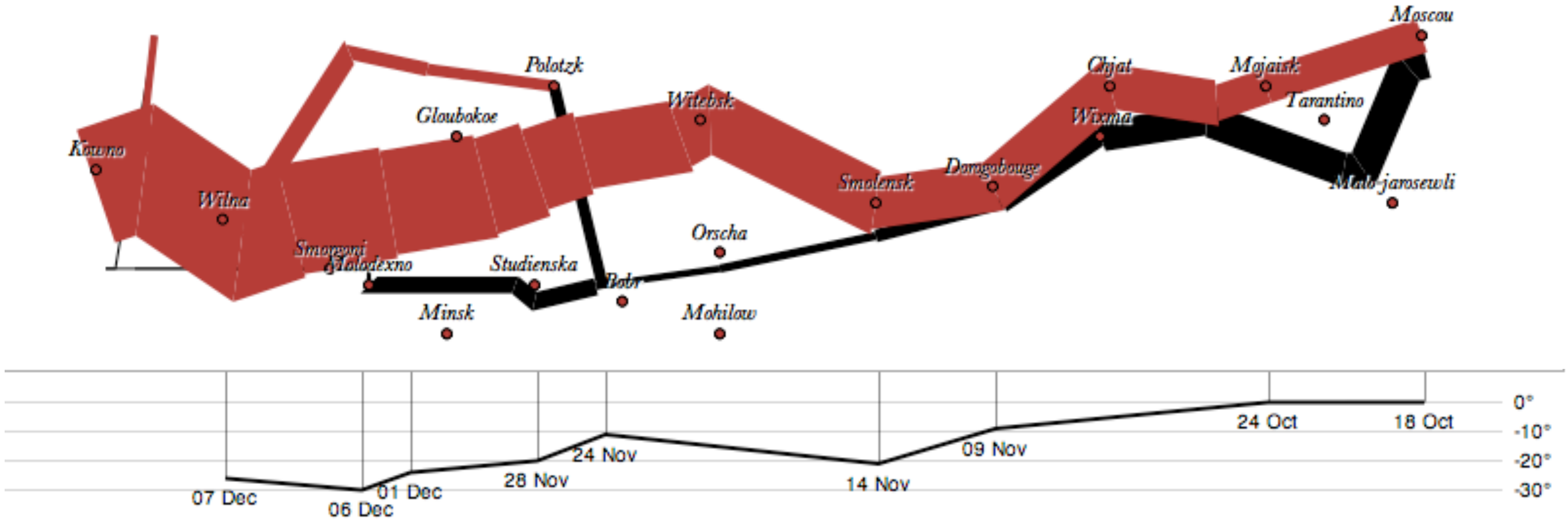
RECT $\lambda : D \rightarrow R$

data	1	1.2	1.7	1.5	0.7
visible	true				
left	λ: index * 25				
bottom	0				
width	20				
height	λ: datum * 80				
fillStyle	blue				
strokeStyle	black				
lineWidth	1.5				
...	...				



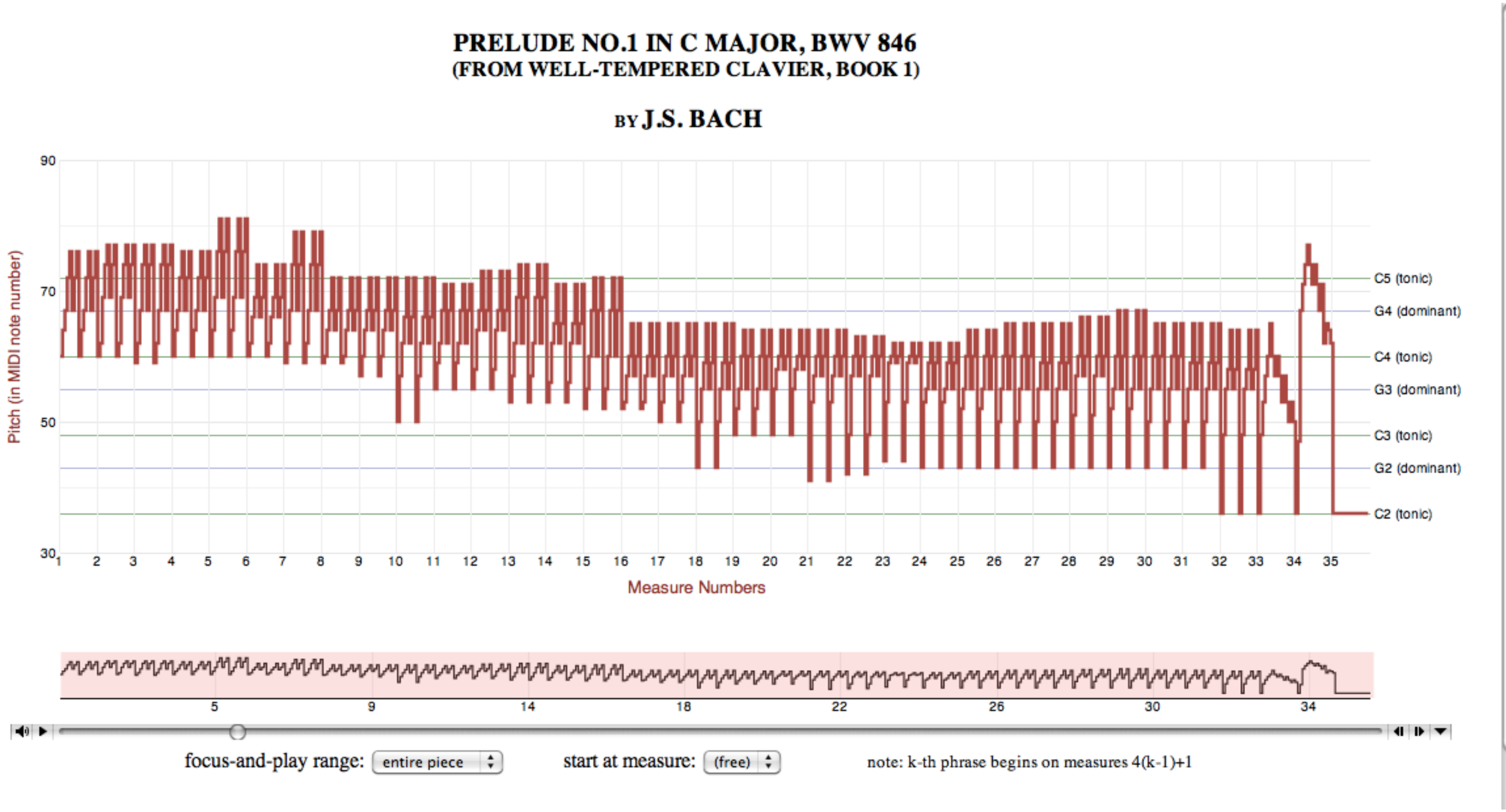
```
var vis = new pv.Panel();
vis.add(pv.Bar)
  .data([1, 1.2, 1.7, 1.5, 0.7])
  .visible(true)
  .left((d) => this.index * 25);
  .bottom(0)
  .width(20)
  .height((d) => d * 80)
  .fillStyle("blue")
  .strokeStyle("black")
  .lineWidth(1.5);
vis.render();
```



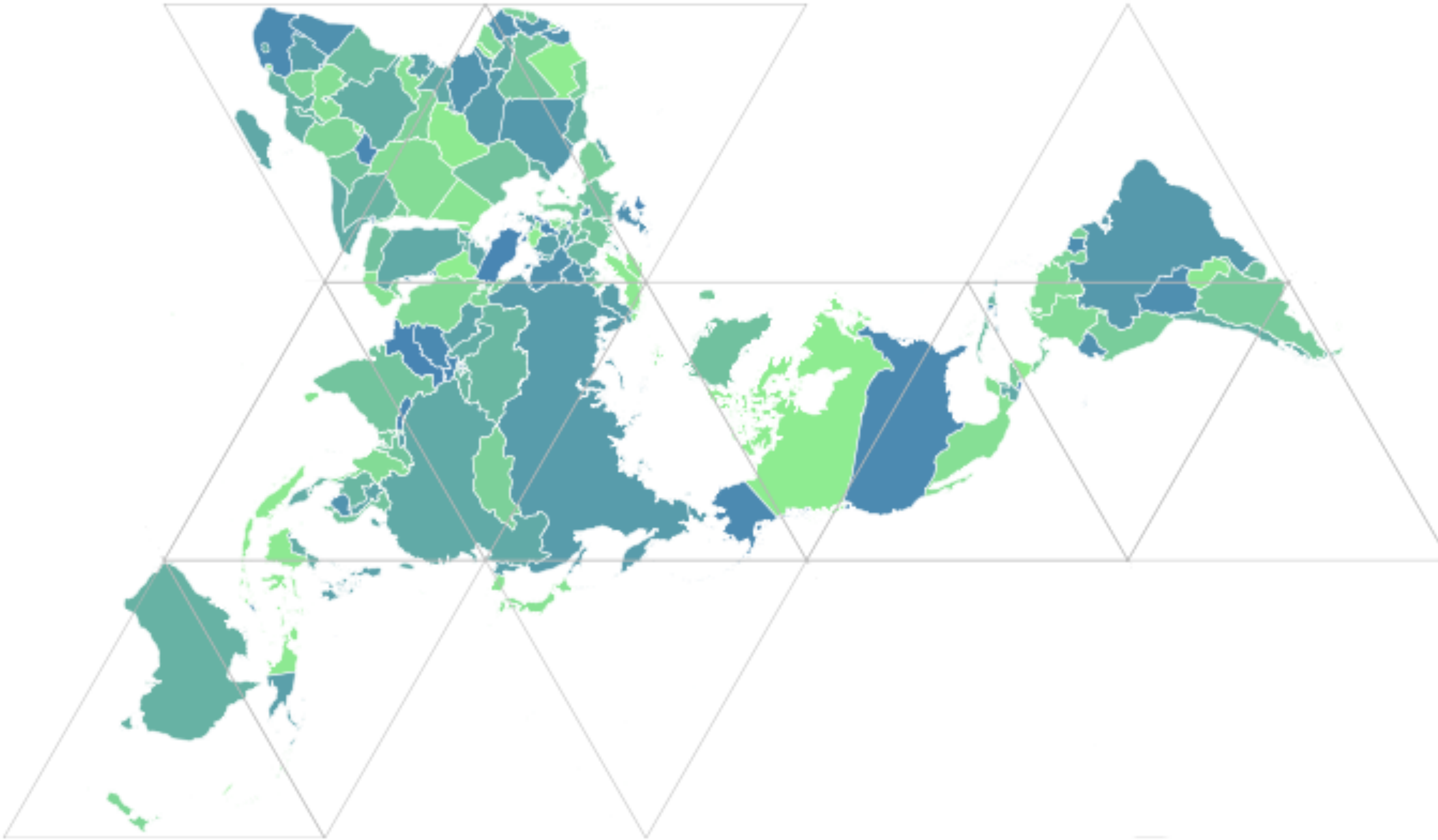



```
var army = pv.nest(napoleon.army, "dir", "group”);
var vis = new pv.Panel();

var lines = vis.add(pv.Panel).data(army);
lines.add(pv.Line)
  .data(() => army[this.idx])
  .left(lon).top(lat).size((d) => d.size/8000)
  .strokeStyle(() => color[army[paneIndex][0].dir]);

vis.add(pv.Label).data(napoleon.cities)
  .left(lon).top(lat)
  .text((d) => d.city).font("italic 10px Georgia")
  .textAlign("center").textBaseline("middle");
```

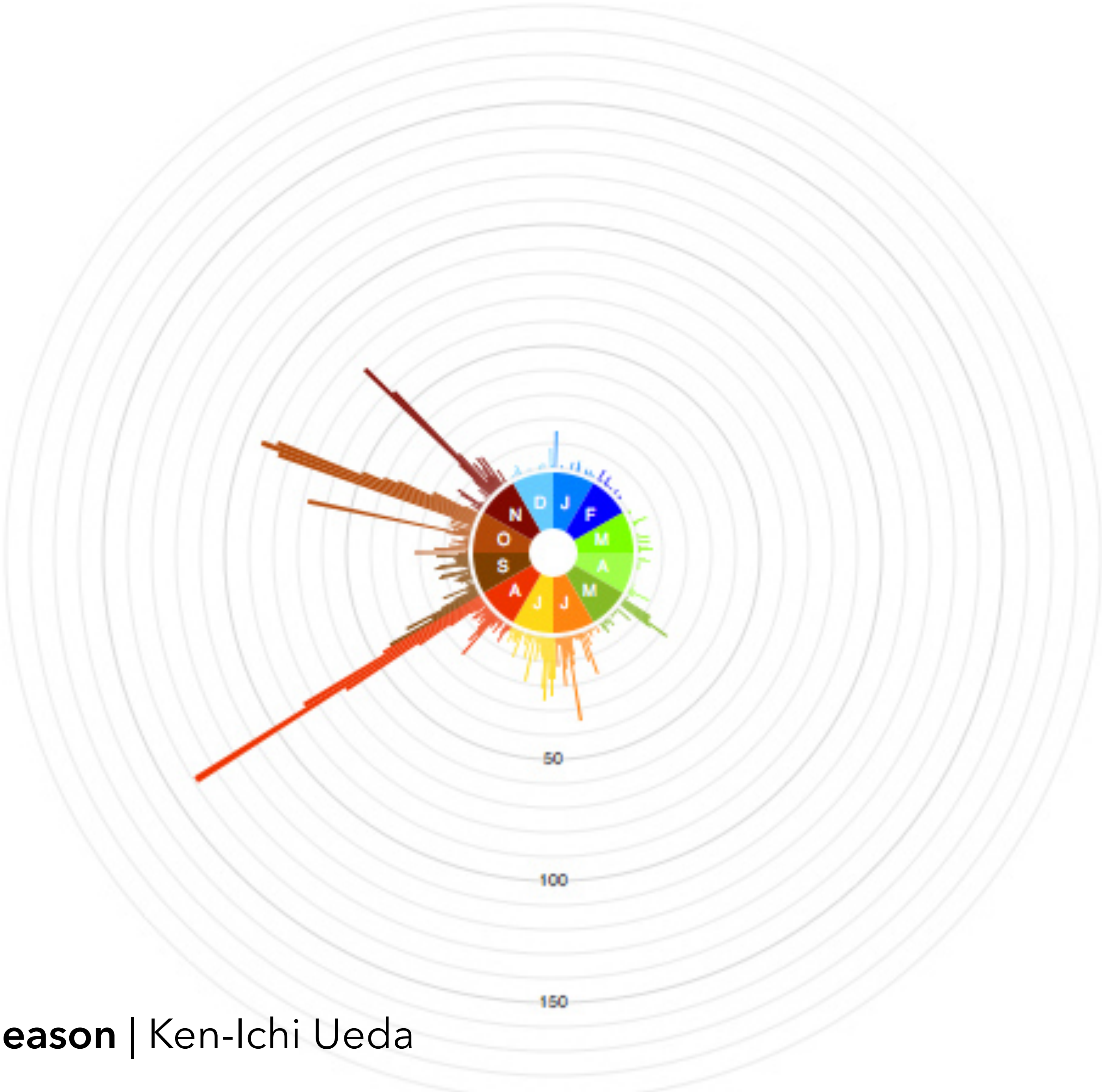
```
vis.add(pv.Rule).data([0,-10,-20,-30])
   .top((d) => 300 - 2*d - 0.5).left(200).right(150)
   .lineWidth(1).strokeStyle("#ccc")
   .anchor("right").add(pv.Label)
     .font("italic 10px Georgia")
     .text((d) => d+"°").textBaseline("center");

vis.add(pv.Line).data(napoleon.temp)
   .left(lon).top(tmp) .strokeStyle("#0")
  .add(pv.Label)
    .top((d) => 5 + tmp(d))
    .text((d) => d.temp+"° "+d.date.substr(0,6))
    .textBaseline("top").font("italic 10px Georgia");
```



Bach's Prelude #1 in C Major | Jieun Oh

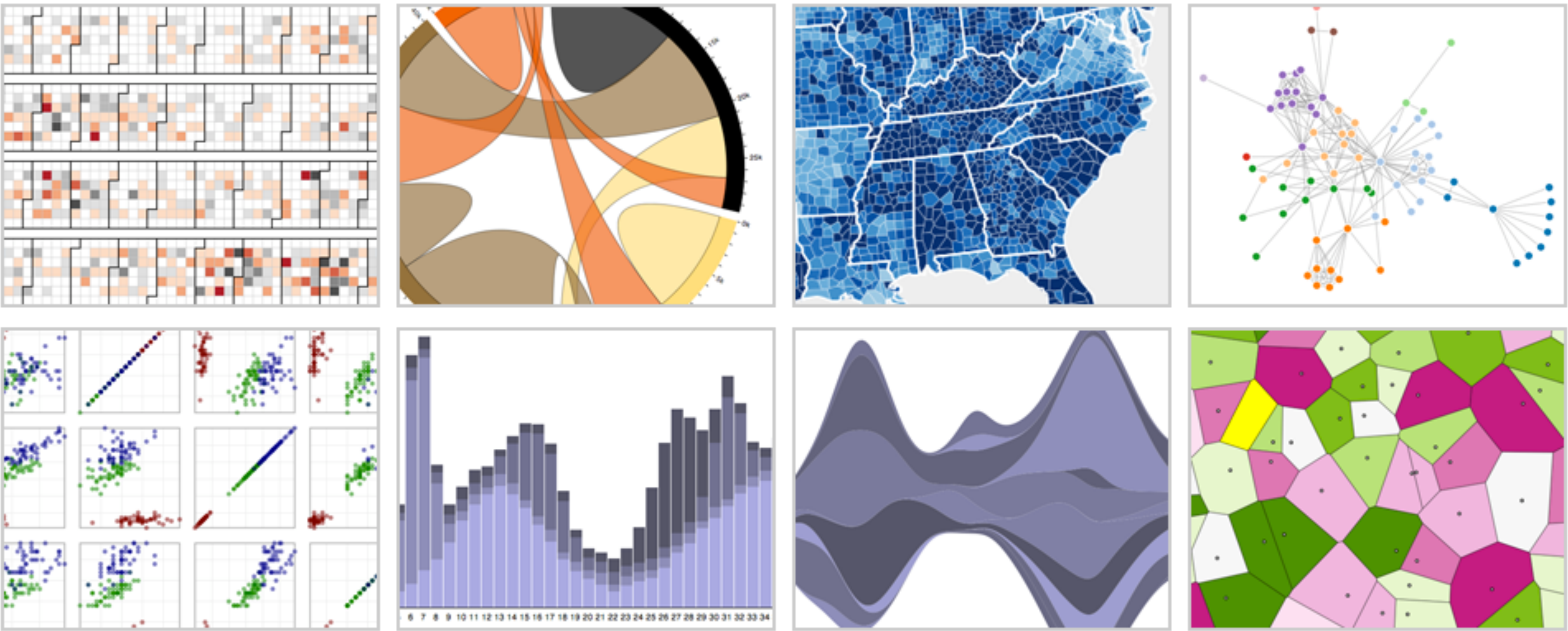


Dymaxion Maps | Vadim Ogievetsky



FlickrSeason | Ken-Ichi Ueda

d3.js Data-Driven Documents



with **Mike Bostock**, Jason Davies & Vadim Ogievetsky

Protovis

Specialized mark types

+ Streamlined design
- Limits expressiveness
- More overhead (slower)
- Harder to debug
- Self-contained model

Specify a scene (nouns)

+ Quick for static vis
- Delayed evaluation
- Animation, interaction
  are more cumbersome

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Specify a scene (nouns)

+ Quick for static vis
- Delayed evaluation
- Animation, interaction are more cumbersome

D3

Bind data to DOM

- Exposes SVG/CSS/…
+ Exposes SVG/CSS/…
+ Less overhead (faster)
+ Debug in browser
+ Use with other tools

Transform a scene (verbs)

- More complex model
+ Immediate evaluation
+ Dynamic data, anim, and interaction natural

D3 Selections

The core abstraction in D3 is a ***selection***.

D3 Selections

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```
// Add and configure an SVG element (<svg width="500" height="300">)
var svg = d3.append("svg")       // add new SVG to page body
    .attr("width", 500)          // set SVG width to 500px
    .attr("height", 300);        // set SVG height to 300px
```

D3 Selections

The core abstraction in D3 is a ***selection***.

```
// Add and configure an SVG element (<svg width="500" height="300">)
var svg = d3.append("svg")     // add new SVG to page body
    .attr("width", 500)        // set SVG width to 500px
    .attr("height", 300);      // set SVG height to 300px

// Select & update existing rectangles contained in the SVG element
svg.selectAll("rect")              // select all SVG rectangles
    .attr("width", 100)            // set rect widths to 100px
    .style("fill", "steelblue");   // set rect fill colors
```

Data Binding

Selections can ***bind*** **data and DOM elements**.

```
var values = [ {…}, {…}, {…}, … ]; // input data as JS objects
```

Data Binding

Selections can ***bind* data and DOM elements**.

```
var values = [ {…}, {…}, {…}, … ]; // input data as JS objects

// Select SVG rectangles and bind them to data values.
var bars = svg.selectAll(“rect.bars”).data(values);
```

Data Binding

Selections can ***bind*** **data and DOM elements**.

var values = [{…}, {…}, {…}, …]; // input data as JS objects

// Select SVG rectangles and bind them to data values.
var bars = svg.selectAll(“rect.bars”).data(values);

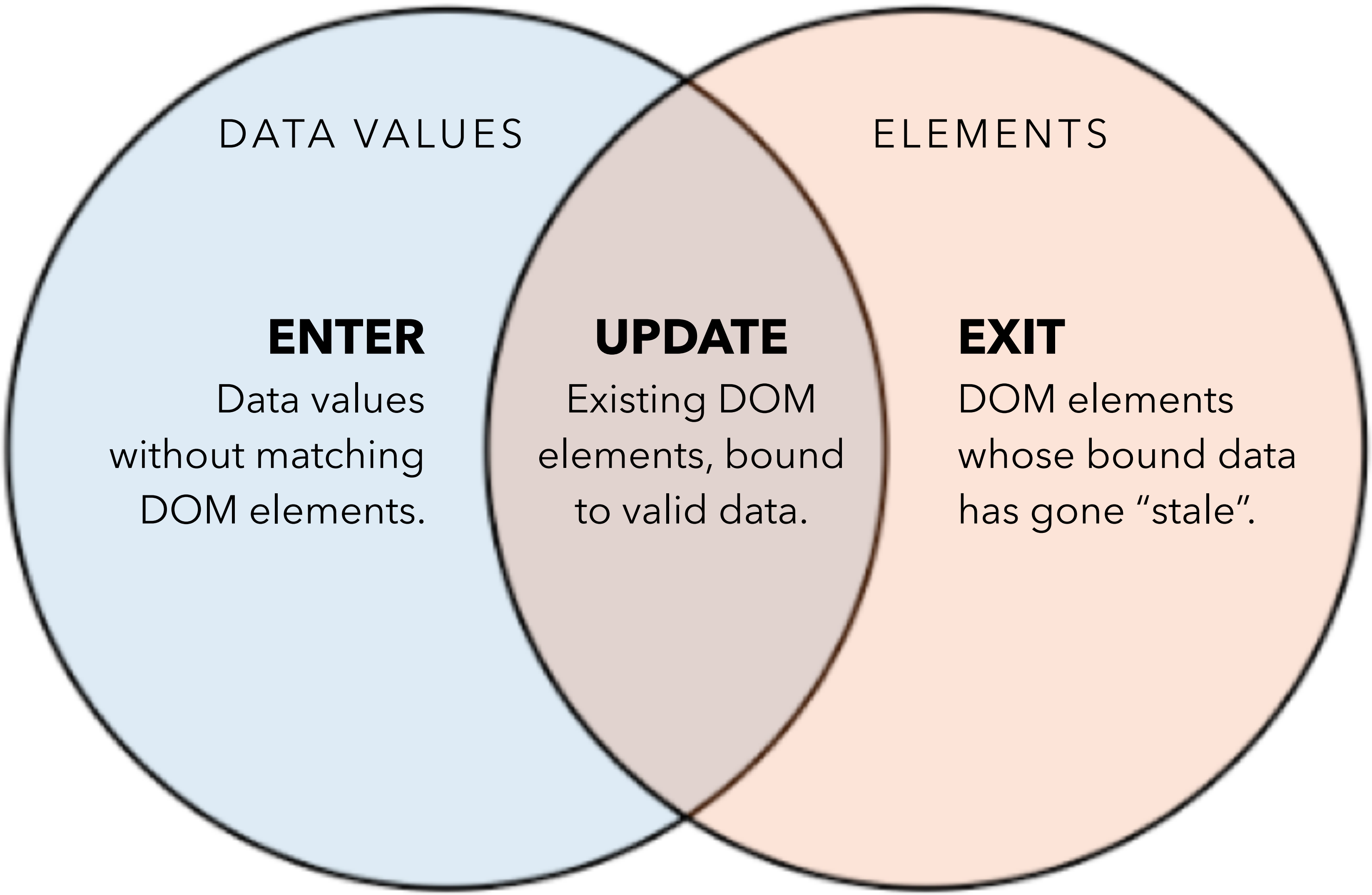
// What if the DOM elements don’t exist yet? The **enter** set represents data
// values that do not yet have matching DOM elements.
bars.enter().append(“rect”).attr(“class”, “bars”);

Data Binding

Selections can ***bind* data and DOM elements**.

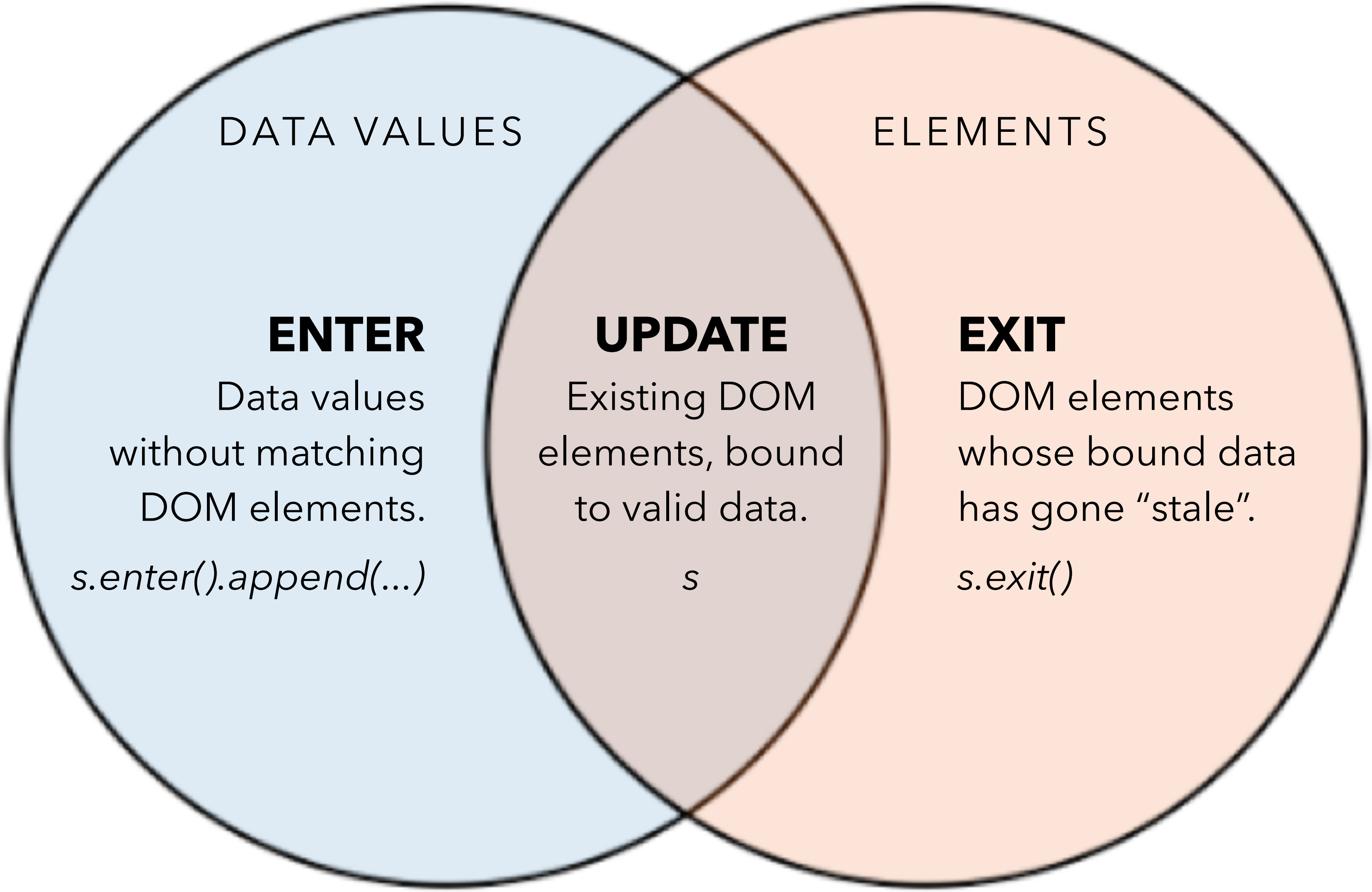
```
var values = [ {…}, {…}, {…}, … ]; // input data as JS objects

// Select SVG rectangles and bind them to data values.
var bars = svg.selectAll("rect.bars").data(values);

// What if the DOM elements don't exist yet? The enter set represents data
// values that do not yet have matching DOM elements.
bars.enter().append("rect").attr("class", "bars");

// What if data values are removed? The exit set is a selection of existing
// DOM elements who no longer have matching data values.
bars.exit().remove();
```

The Data Join



The Data Join

var s = d3.selectAll(...).data(...)



Data Binding

Selections can ***bind* data and DOM elements**.

```
var values = [ {…}, {…}, {…}, … ]; // input data as JS objects

// Select SVG rectangles and bind them to data values.
var bars = svg.selectAll(“rect.bars”).data(values)
    .join(
        enter => enter.append("rect"), // create new
        update => update,              // update current
        exit => exit.remove()          // remove outdated
    )
```

D3 Modules

Data Parsing / Formatting (JSON, CSV, …)
Shape Helpers (arcs, curves, areas, symbols, …)
Scale Transforms (linear, log, ordinal, …)
Color Spaces (RGB, HSL, LAB, …)
Animated Transitions (tweening, easing, …)
Geographic Mapping (projections, clipping, …)
Layout Algorithms (stack, pie, force, trees, …)
Interactive Behaviors (brush, zoom, drag, …)

Many of these correspond to future lecture topics!

Ease-of-Use

Expressiveness

Chart Typologies

Excel, Many Eyes, Google Charts

Visual Analysis Grammars

VizQL, ggplot2

Visualization Grammars

Protovis, D3.js

Component Architectures

Prefuse, Flare, Improvise, VTK

Graphics APIs

Canvas, OpenGL, Processing

Administrivia

A2: Deceptive Visualization

Design **two** static visualizations for a dataset:

1. An *earnest* visualization that faithfully conveys the data
2. A *deceptive* visualization that tries to mislead viewers

Your two visualizations may address different questions.

Try to design a deceptive visualization that appears to be earnest: *can you trick your classmates and course staff?*

You are free to choose your own dataset, but we have also provided some preselected datasets for you.

Submit two images and a brief write-up on Gradescope.

Due by **Wed 4/18 11:59pm**.

DONE

A2 Peer Reviews

You have been assigned two peer A2 submissions to review. For each:

- Try to determine which is earnest and which is deceptive
- Share a rationale for how you made this determination
- Share feedback using the “I Like / I Wish / What If” rubric

Assigned reviews will be posted on the A2 Peer Review page on Canvas, along with a link to a Google Form. You should submit two forms: one for each A2 peer review.

Due by **Wed 4/26 11:59pm**.

I Like… / I Wish… / What If?

I LIKE…

Praise for design ideas and/or well-executed implementation details. *Example: "I like the navigation through time via the slider; the patterns observed as one moves forward are compelling!"*

I WISH…

Constructive statements on how the design might be improved or further refined. *Example: "I wish moving the slider caused the visualization to update immediately, rather than the current lag."*

WHAT IF?

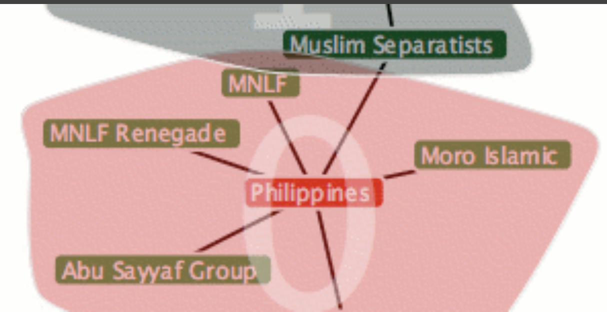
Suggest alternative design directions, or even wacky half-baked ideas. *Example: "What if we got rid of the slider and enabled direct manipulation navigation by dragging data points directly?"*

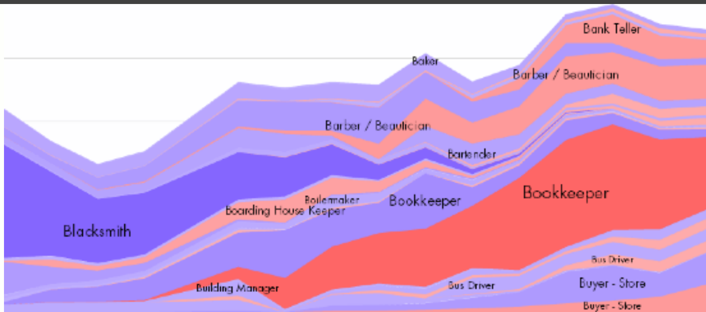
A3: Interactive Prototype

Create an interactive visualization. Choose a driving question for a dataset and develop an appropriate visualization + interaction techniques, then deploy your visualization on the web.

Due by *11:59pm* on **Monday, May 8**.

Work in project teams of 3-4 people.





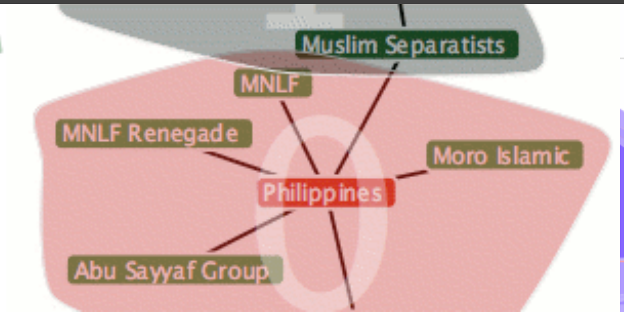
Form A3 + Final Project Team

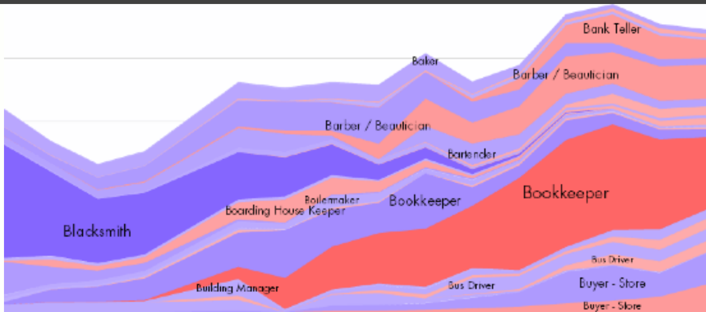
Form a **team of 3-4** for A3 and the Final Project.

Submit signup form by **Thur 4/27, 11:59pm**.

If you do not have team mates, post on Ed about your interests/skills/project ideas!

We will send out a reminder early next week.



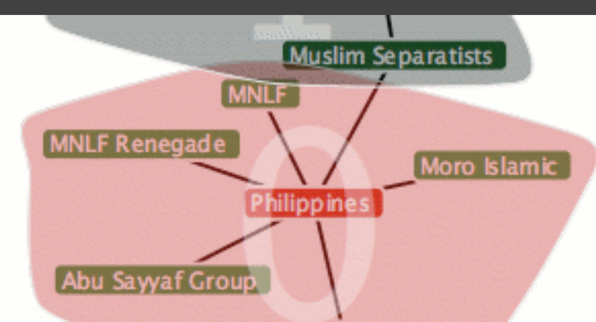


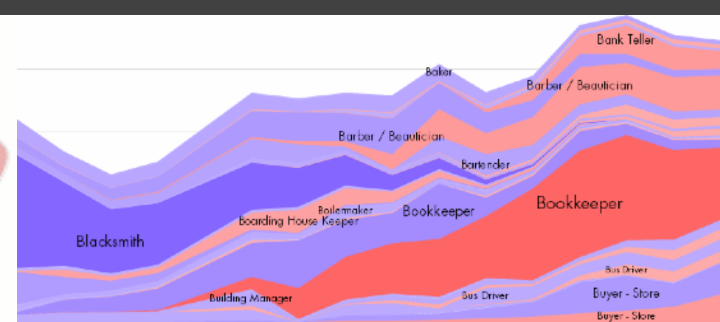
Requirements

Interactive. You must implement interaction methods! However, this is not only selection / filtering / tooltips. Also consider annotations or other narrative features to draw attention and provide additional context

Web-based. D3/Vega-Lite are encouraged, but not required. Deploy to web using GitHub pages.

Write-up. Provide design rationale.



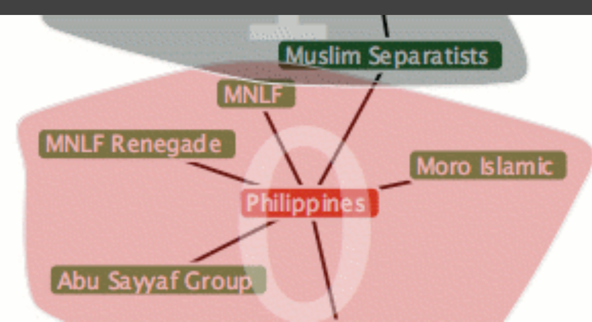


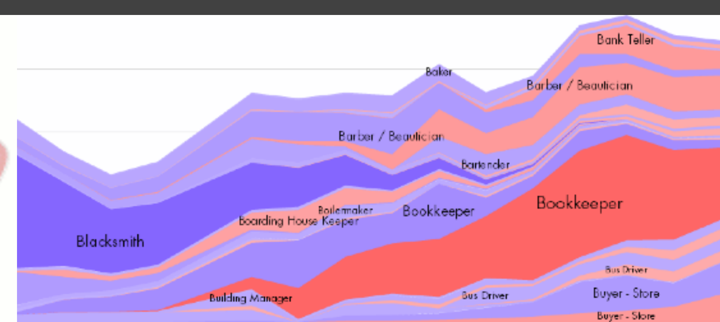
Interactive Prototype Tips

Start now. It will take longer than you think.

Keep it simple. Choose a *minimal* set of interactions that enables users to explore and generate interesting insights. Do not feel obligated to convey *everything* about the data: focus on a compelling subset.

Promote engagement. How do your chosen interactions reveal interesting observations?





D3 Tutorial - In Class Thu Apr 27

D3.js Deep Dive led by Luke and Sebastin

Be sure to read the D3, Part 1 notebook ahead of time. We'll work through Part 2 in class. Also read the JS/Observable primer if you're new to this!

A Visualization Tool Stack

Chart Typologies

Excel, Many Eyes, Google Charts

Visual Analysis Grammars

VizQL, ggplot2

Visualization Grammars

Protovis, D3.js

Component Architectures

Prefuse, Flare, Improvise, VTK

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What is a Declarative Language?

Programming by describing *what*, not *how*

Separate **specification** (*what you want*) from **execution** (*how it should be computed*)

In contrast to **imperative programming**, where you must give explicit steps.

What is a Declarative Language?

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Separate **specification** (*what you want*) from **execution** (*how it should be computed*)

In contrast to **imperative programming**, where you must give explicit steps.

```
d3.selectAll("rect")
  .data(my_data)
 .join("rect")
  .attr("x", d => xscale(d.foo))
  .attr("y", d => yscale(d.bar))
```

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The New York Times

Tuesday, October 26, 2010 Last Update: 3:50 PM ET

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— 2010 Midterm Elections —

Tea Party Vow to Deter Voter Fraud Is Called Scare Tactic

By IAN URBINA 2:19 PM ET

Voting rights group say that Tea Party members' plan to question voters' eligibility at the polls is intended to suppress minority and poor voters.

Post a Comment | Read (355)

Glaxo Pays $750 Million Fine for Tainted Products

By GARDINER HARRIS and DUFF

Joshua Kristal for The New York Times

Painting at 99, With No Compromises

By ROBIN FINN

An exhibition celebrating Will Barnet's centennial year traces his evolution as a modern American artist.

OPINION »

OP-ED CONTRIBUTOR

Humans to Asteroids: Watch Out!

How to keep near-Earth objects from hitting us.

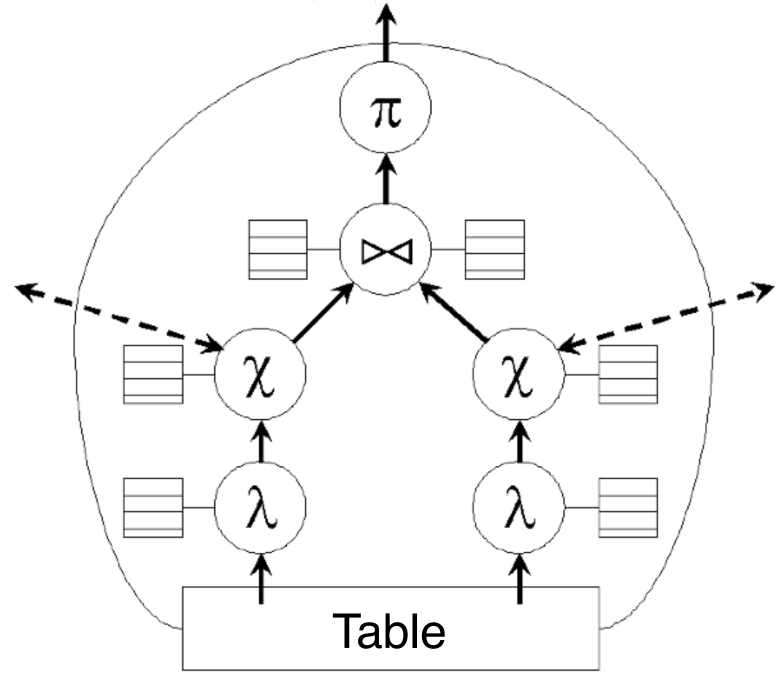
- Brooks: No Second Thoughts | Comments (200)
- Herbert: The Corrosion of America
- Cohen: Turkey Steps Out
- Editorial: Mortgage Mess
- Bloggingheads: Jon Stewart's Power

MARKETS » At 3:56 PM ET

S.&P. 500 | Dow | Nasdaq

```
<!DOCTYPE html PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN"
"http://www.w3.org/TR/html4/loose.dtd">
<!--[if IE]><![endif]-->
▼<html>
 ▶<head>…</head>
 ▼<body id="home" style="visibility: visible; ">
   <script src="http://connect.facebook.net/en_US/all.js"></scrip
   <div id="fb-root"></div>
   <a name="top"></a>
  ▼<div id="shell">
   ▶<ul id="memberTools">…</ul>
     <!-- ADXINFO classification="text_ad" campaign="nyt2010-circ-
   ▶<div class="tabsContainer">…</div>
     <!-- close .tabsContainer -->
   ▶<div id="page" class="tabContent active">…</div>
     <!--close page -->
   </div>
   <!--close shell -->
  ▶<script type="text/javascript" language="JavaScript">…</script
   <img src="/adx/bin/clientside/
   1b1a1755Q2F,.tWdC,KiQ2BCQ5C6iSM.KCYQ2FMadYYQ24xN!Q2B!xQ24WN4aN
   <script src="http://graphics8.nytimes.com/js/test/wto/wt_capi.
   charset="utf-8"></script>
   <span id="wtoScript"></span>
  ▶<script type="text/javascript">…</script>
   <img src="http://graphics8.nytimes.com/ads/blank.gif">
   <script type="text/javascript" src="http://graphics8.nytimes.c
```

HTML / CSS




```sql
SELECT customer_id, customer_name,
    COUNT(order_id) as total
FROM customers
INNER JOIN orders ON
    customers.customer_id
    = orders.customer_id
GROUP BY customer_id, customer_nam
HAVING COUNT(order_id) > 5
ORDER BY COUNT(order_id) DESC
```

SQL

Why Declarative Languages?

Faster iteration, less code, larger user base?

Better visualization. *Smart defaults.*

Reuse. *Write-once, then re-apply.*

Performance. *Optimization, scalability.*

Portability. *Multiple devices, renderers, inputs.*

Programmatic generation.
Write programs which output visualizations.
Automated search & recommendation.

Chart Typologies

Excel, Many Eyes, Google Charts

Charting Tools

Visual Analysis Grammars

VizQL, ggplot2

Visualization Grammars

Protovis, D3.js

Declarative Languages

Component Architectures

Prefuse, Flare, Improvise, VTK

Programming Toolkits

Graphics APIs

Processing, OpenGL, Java2D

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Charting Tools

Visual Analysis Grammars

VizQL, ggplot2, ***Vega-Lite***

Visualization Grammars

Protovis, D3.js, ***Vega***

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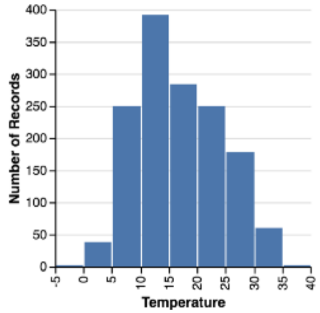
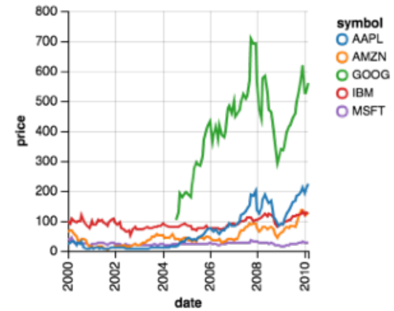
Programming Toolkits

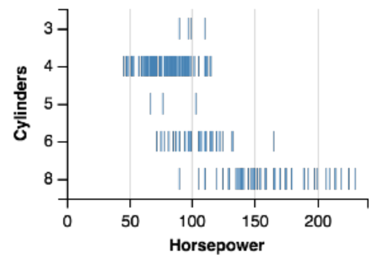
Histogram



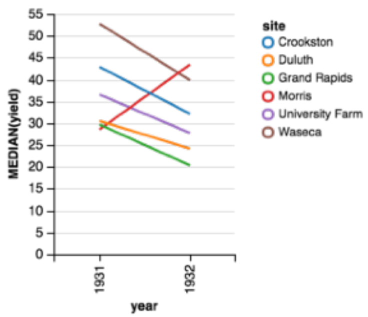
Line Chart



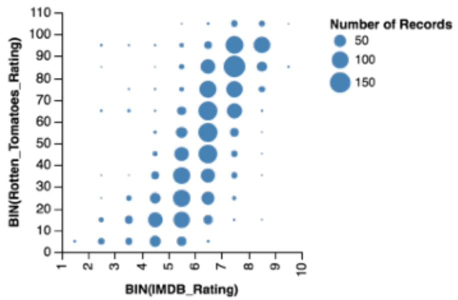
Strip Plot



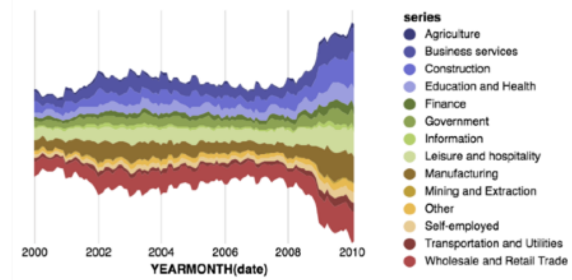
Slope Graph



Binned Scatter Plot

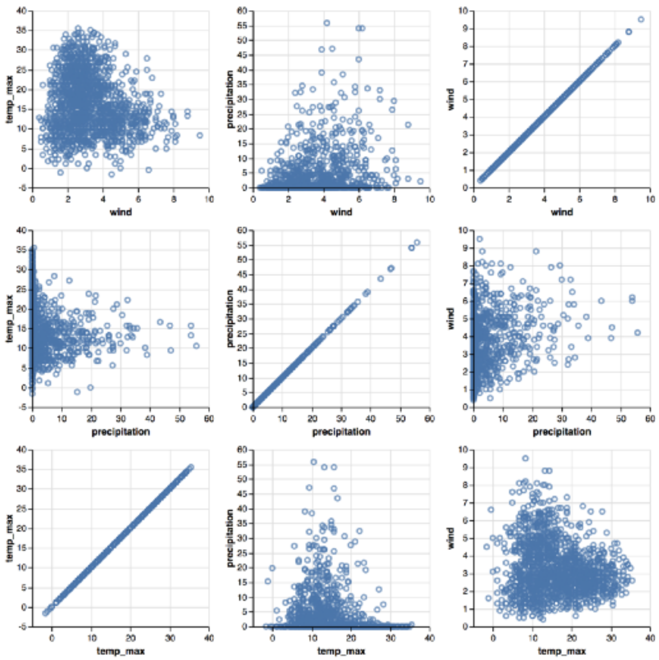


Area Chart

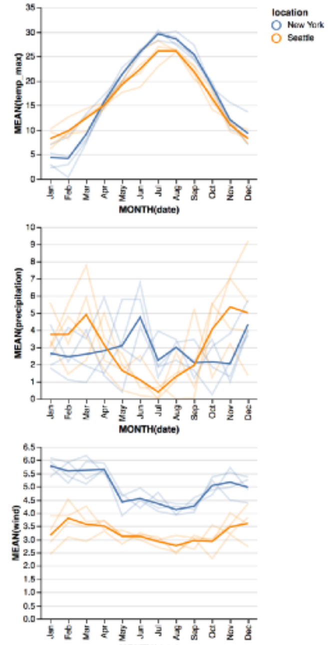


Vega-Lite: A Grammar of Graphics

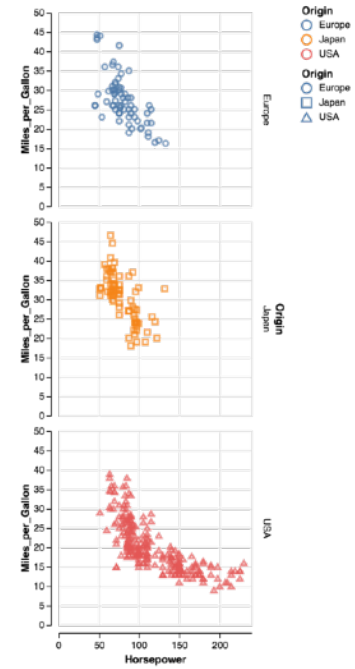
Scatter Plot Matrix



Concat & Layered Views

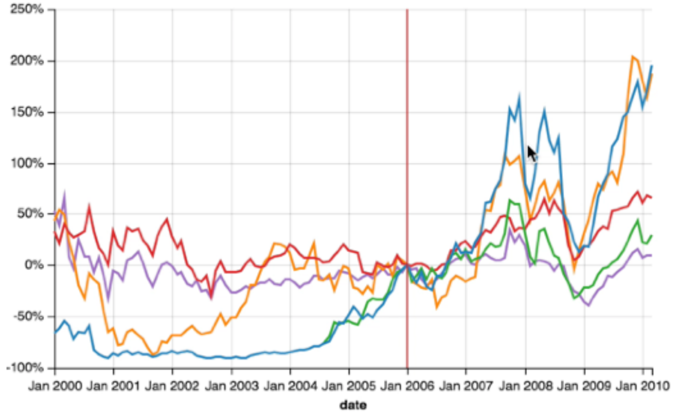


Faceted Views

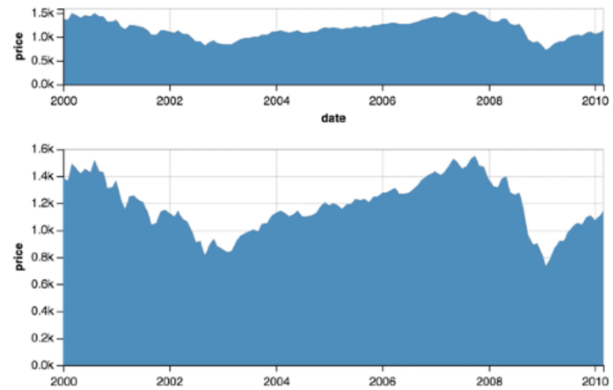


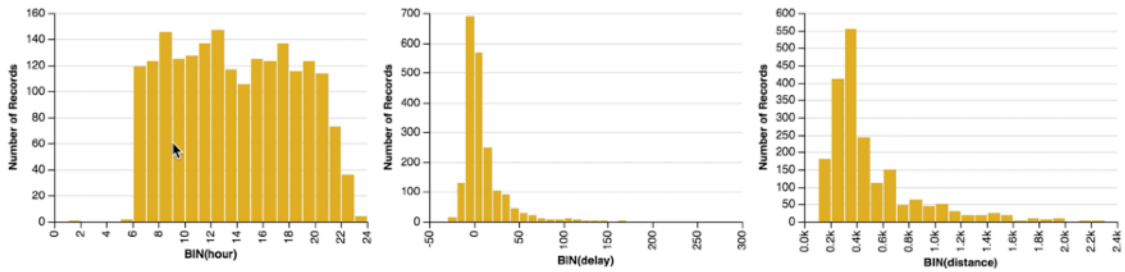
Vega-Lite: A Grammar of Multi-View Graphics

Indexed Chart



Focus + Context

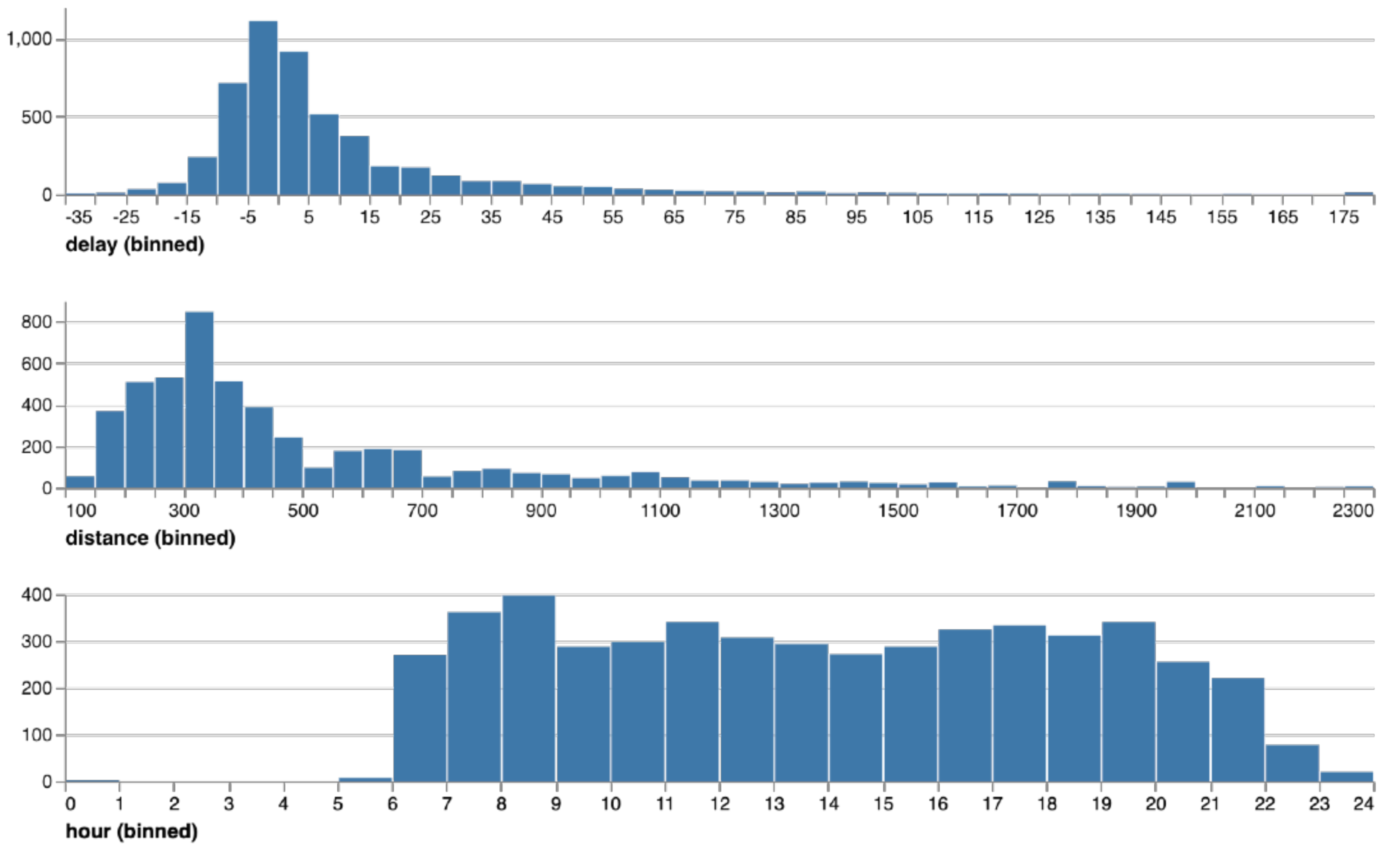




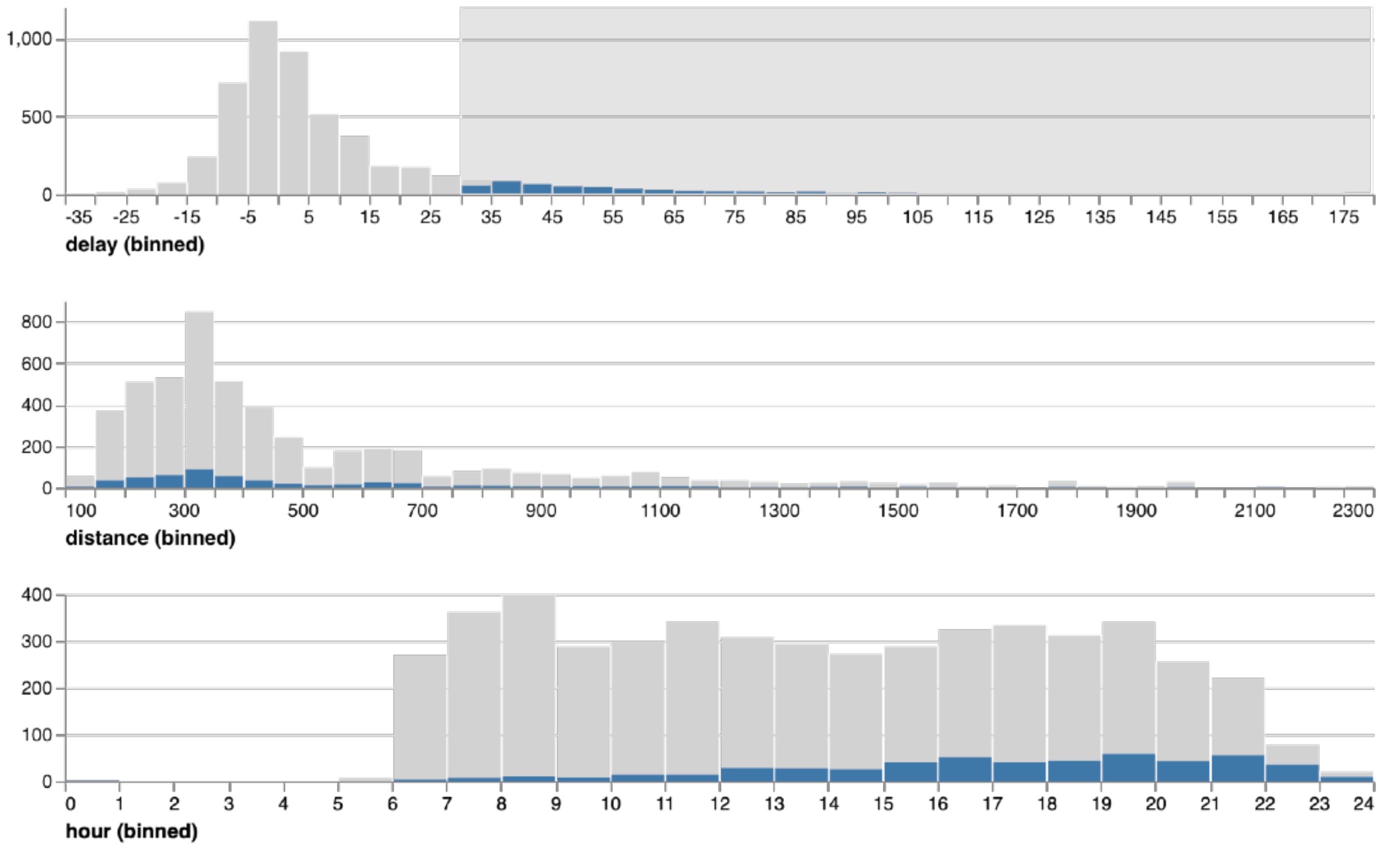
Cross-Filtering

Vega-Lite: A Grammar of Interactive Graphics

Cross-Filtering in Vega-Lite

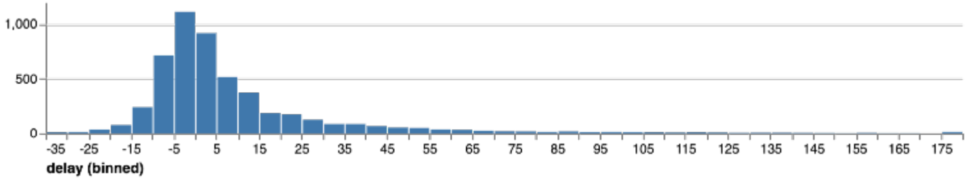


Cross-Filtering in Vega-Lite



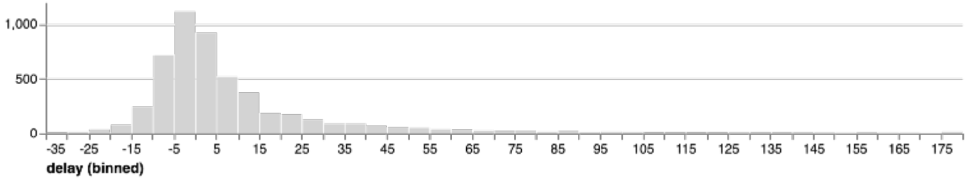
Cross-Filtering in Vega-Lite

```
markBar().encode(
  x().fieldQ('delay').bin(true),
  y().count()
).data('data/flights.json')
```



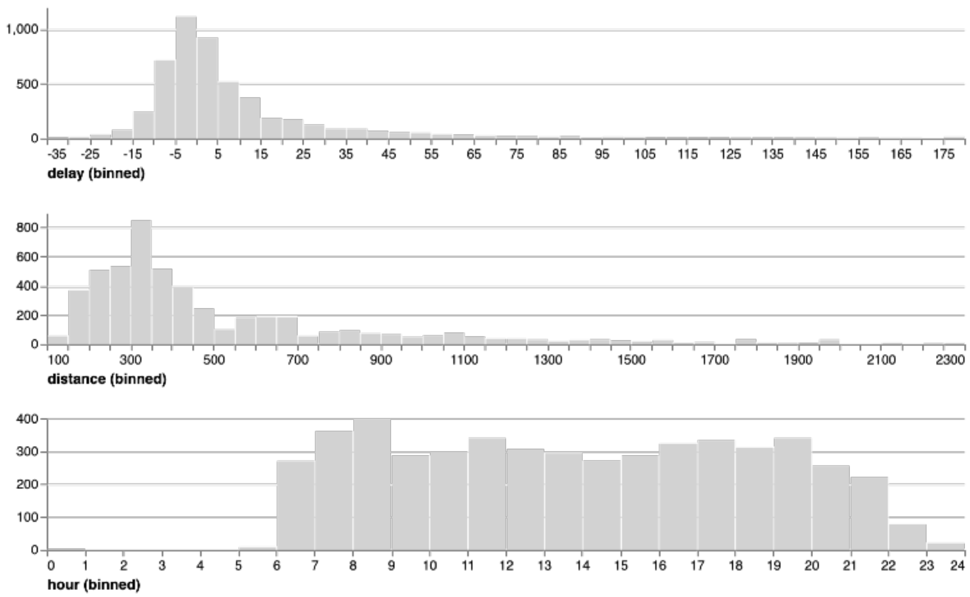
Cross-Filtering in Vega-Lite

```
markBar().encode(
  x().fieldQ('delay').bin(true),
  y().count(),
  color().value('lightgrey')
).data('data/flights.json')
```



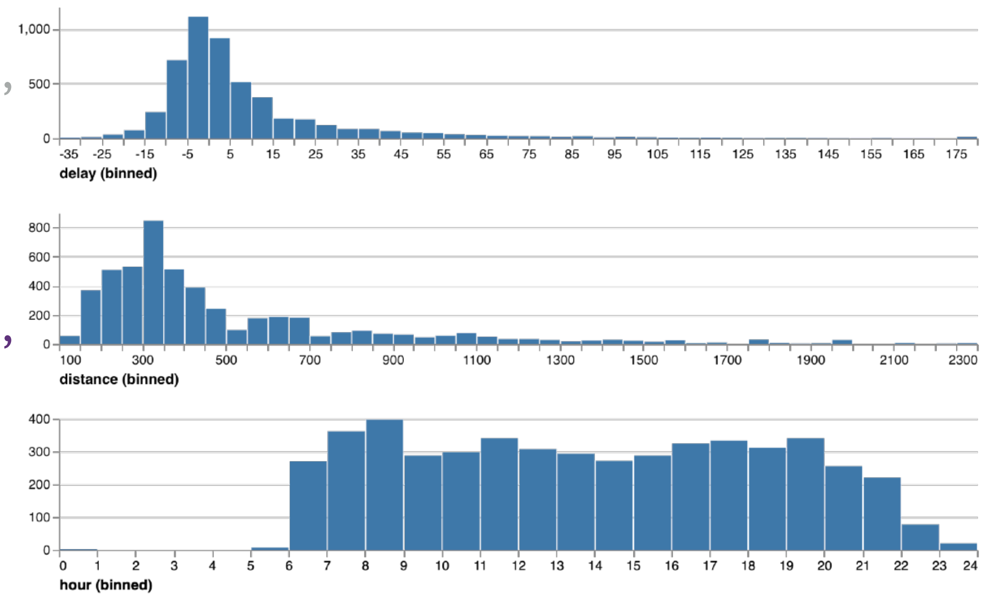
Cross-Filtering in Vega-Lite

```
markBar().encode(
  x().fieldQ(repeat('row').bin(true),
  y().count(),
  color().value('lightgrey')
)
.repeat({
  row: ['delay', 'distance', 'hour']
 })
.data('data/flights.json')
```



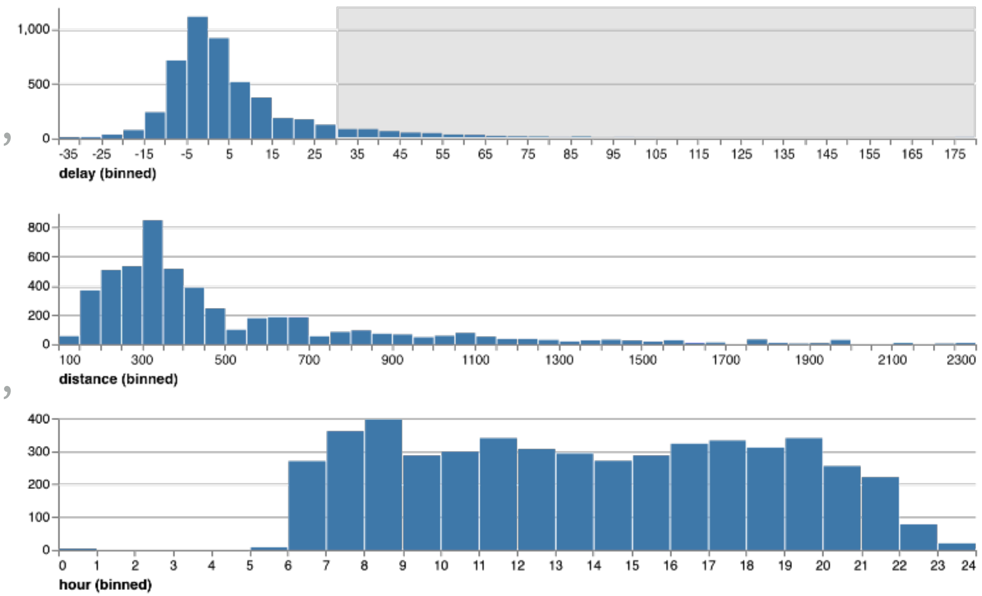
Cross-Filtering in Vega-Lite

```
layer(
  markBar().encode(
    x().fieldQ(repeat('row')).bin(true),
    y().count(),
    color().value('lightgrey')
  ),
  markBar().encode(
    x().fieldQ(repeat('row')).bin(true),
    y().count()
  )
)
.repeat({
  row: ['delay', 'distance', ‘hour']
})
.data('data/flights.json')
```



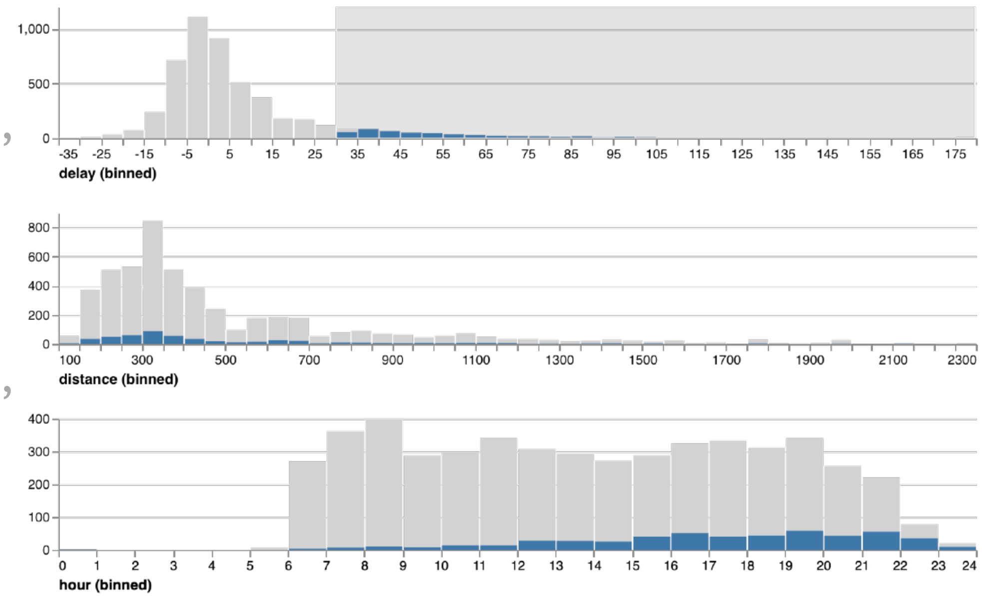
Cross-Filtering in Vega-Lite

```
brush = selectInterval().encodings('x')

layer(
  markBar().encode(
    x().fieldQ(repeat('row')).bin(true),
    y().count(),
    color().value('lightgrey')
  ).params(brush),
  markBar().encode(
    x().fieldQ(repeat('row')).bin(true),
    y().count()
  )
)
.repeat({
  row: ['delay', 'distance', ‘hour']
})
.data('data/flights.json')
```



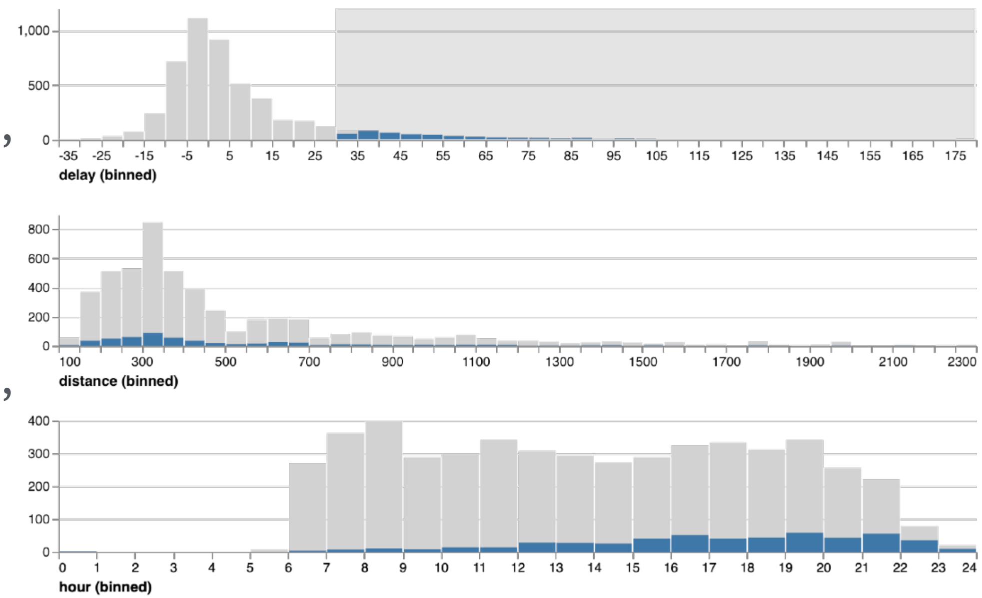
Cross-Filtering in Vega-Lite

```
brush = selectInterval.encodings('x')

layer(
  markBar().encode(
    x().fieldQ(repeat('row')).bin(true),
    y().count(),
    color().value('lightgrey')
  ).params(brush),
  markBar().encode(
    x().fieldQ(repeat('row')).bin(true),
    y().count()
  ).transform(filter(brush))
)
.repeat({
  row: ['delay', 'distance', ‘hour']
})
.data('data/flights.json')
```



Cross-Filtering in Vega-Lite

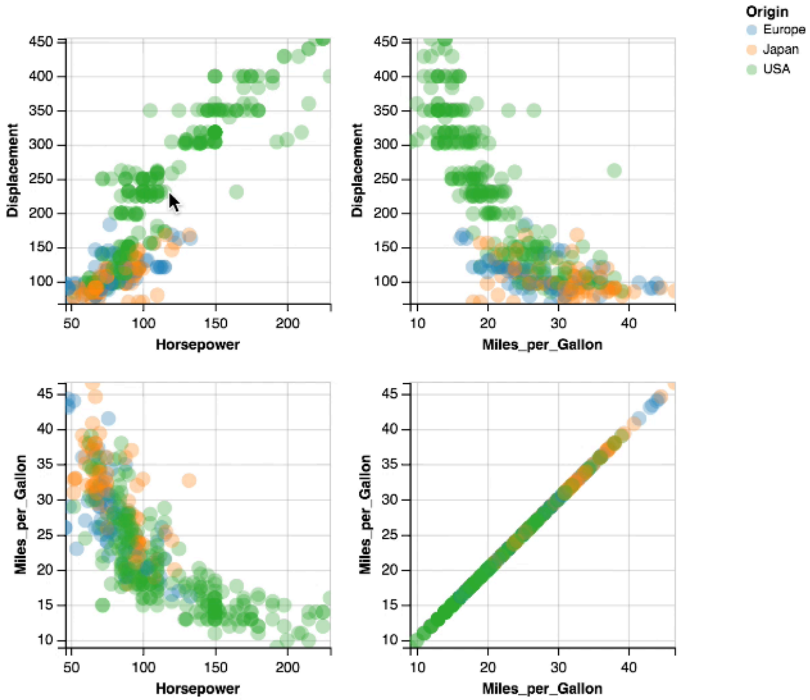
```
brush = selectInterval.encodings('x')

layer(
  markBar().encode(
    x().fieldQ(repeat('row')).bin(true),
    y().count(),
    color().value('lightgrey')
  ).params(brush),
  markBar().encode(
    x().fieldQ(repeat('row')).bin(true),
    y().count()
  ).transform(filter(brush))
)
.repeat({
  row: ['delay', 'distance', ‘hour']
})
.data('data/flights.json')
```



Multi-view interactive graphics in ~10 lines of code

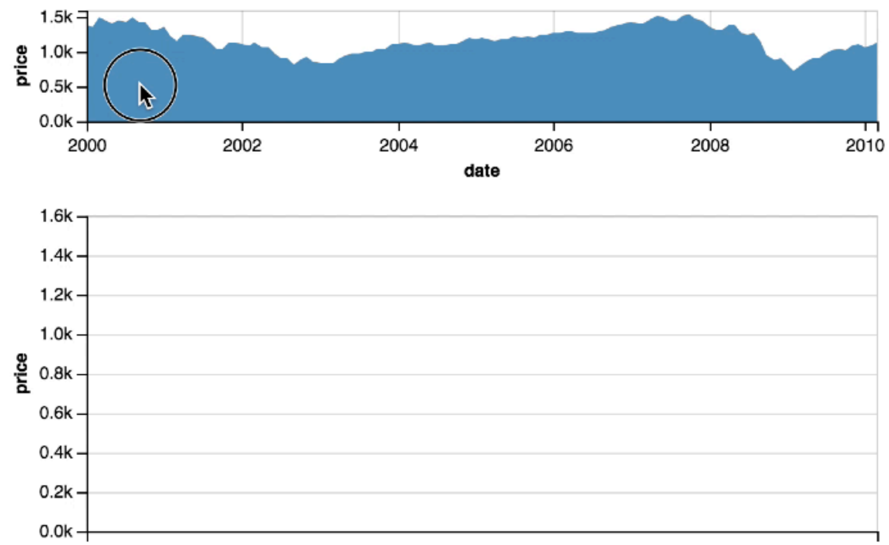
Selections

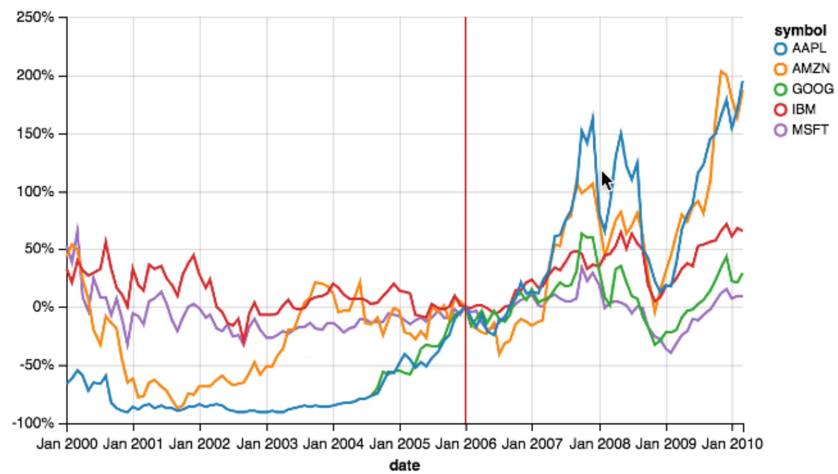
Selections *invert* scales and *parameterize* graphics



Bind selection to scale domains:
Synchronized Pan & Zoom!

Overview + Detail





Parameterized Transformations

Chart Typologies

Excel, Many Eyes, Google Charts

Charting Tools

Visual Analysis Grammars

VizQL, ggplot2, ***Vega-Lite***

Visualization Grammars

Protovis, D3.js, ***Vega***

Declarative Languages

Component Architectures

Prefuse, Flare, Improvise, VTK

Programming Toolkits

Graphics APIs

Processing, OpenGL, Java2D

Chart Typologies

Excel, Many Eyes, Google Charts

?!

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Interactive Data Exploration

Tableau, ***Lyra, Voyager***

Graphical Interfaces

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UW Interactive Data Lab PROJECTS

The Lyra Visualization Design Environment (VDE) alpha

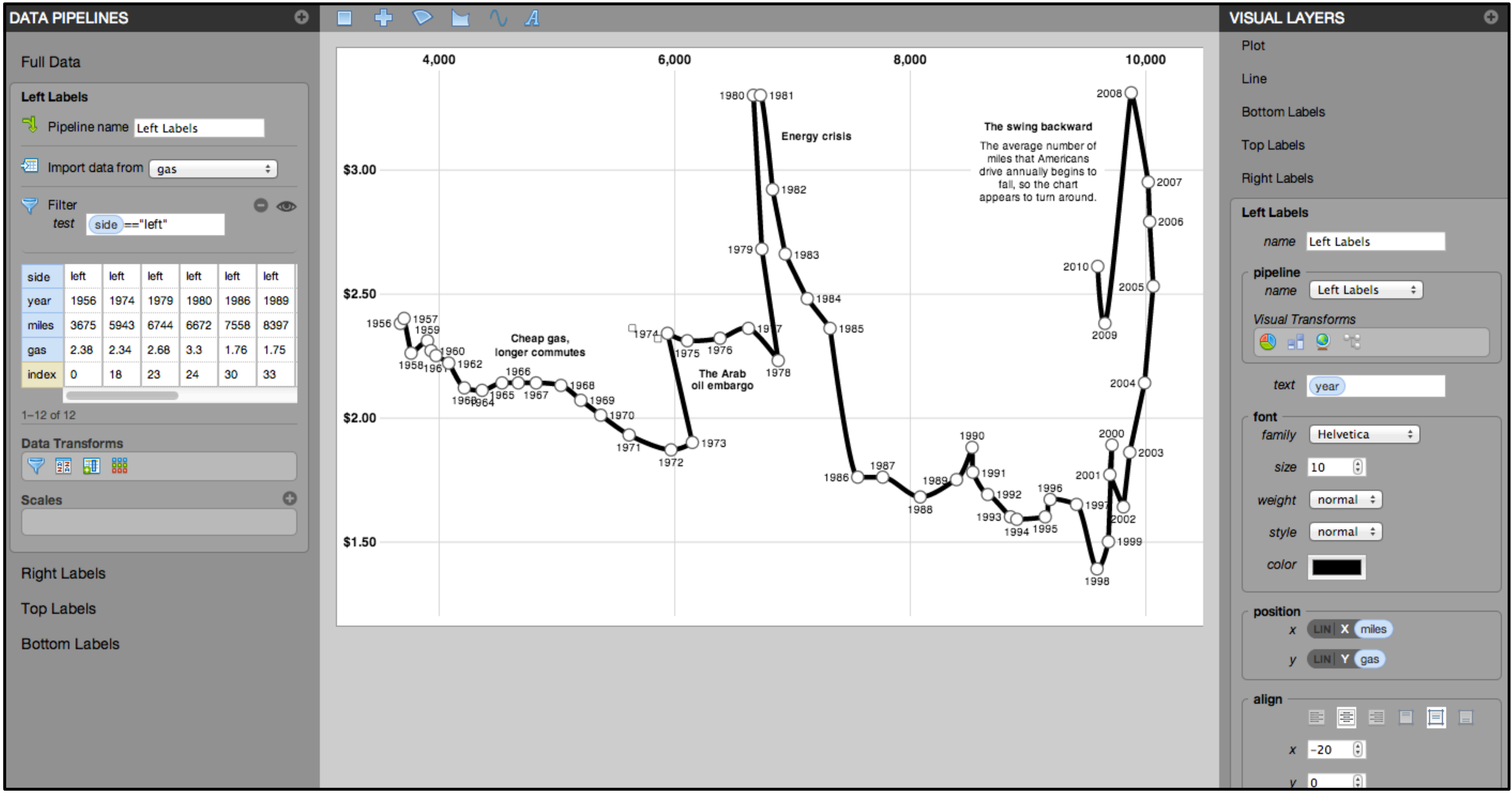
Arvind Satyanarayan, Kanit "Ham" Wongsuphasawat, Jeffrey Heer

William Playfair's classic chart comparing the price of wheat and wages in England recreated in the Lyra VDE.

idl.cs.washington.edu/projects/lyra

See also: Charticulator, Data Illustrator

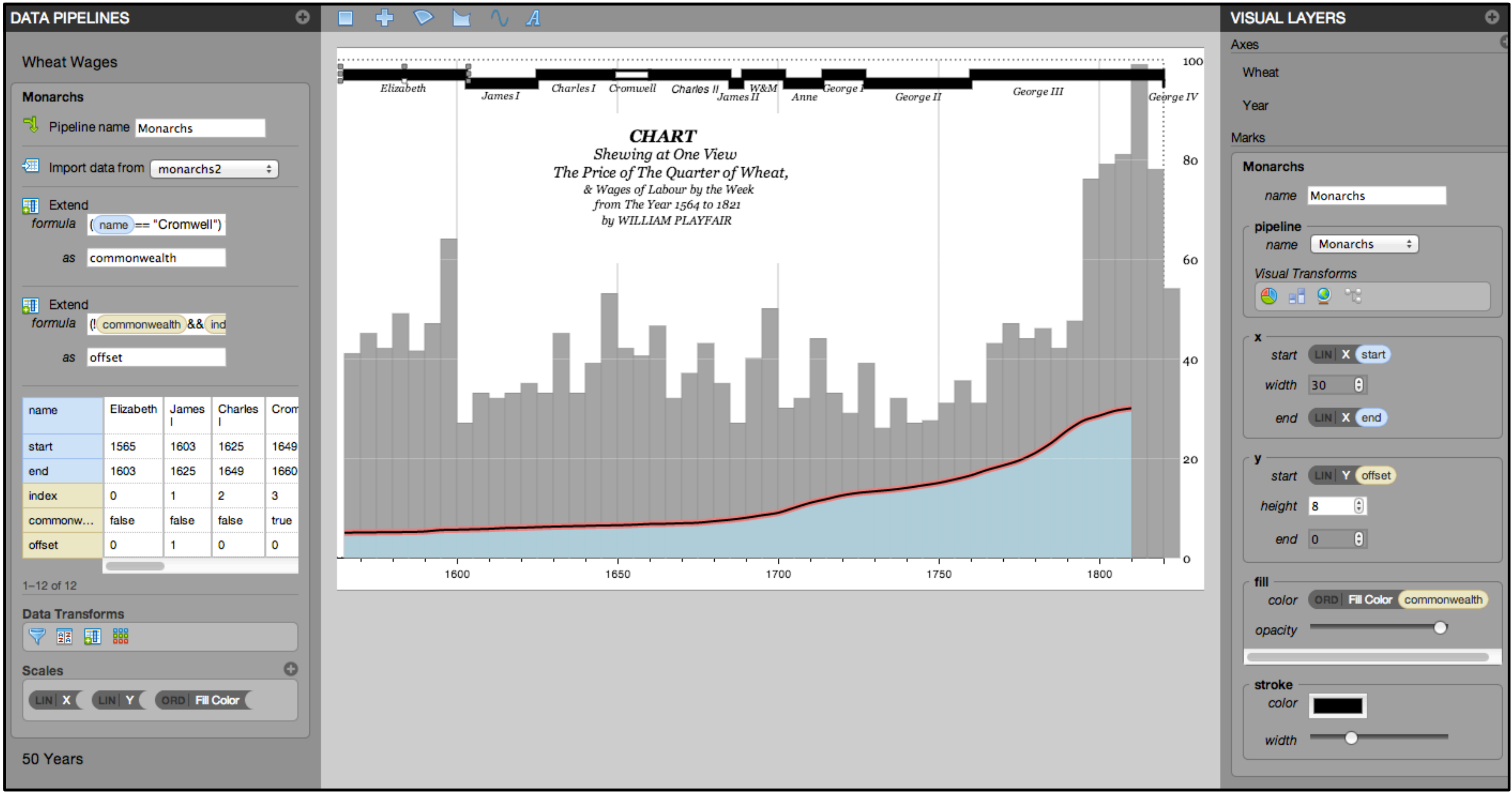
Lyra A Visualization Design Environment



side	left	left	left	left	left	left
year	1956	1974	1979	1980	1986	1989
miles	3675	5943	6744	6672	7558	8397
gas	2.38	2.34	2.68	3.3	1.76	1.75
index	0	18	23	24	30	33

Driving Shifts into Reverse by Hannah Fairfield, NYTimes

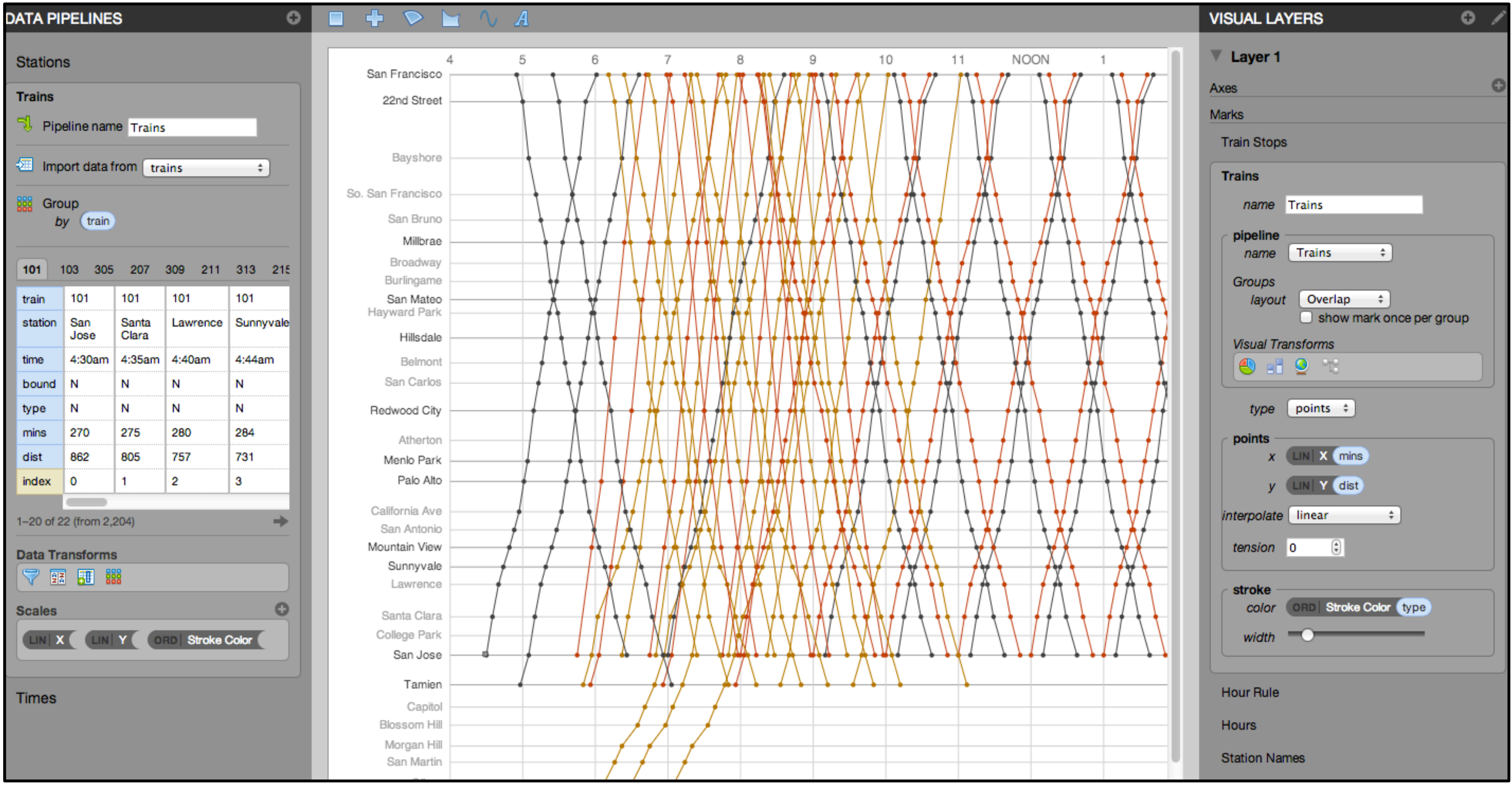
Lyra A Visualization Design Environment



name	Elizabeth	James I	Charles I	Crom
start	1565	1603	1625	1649
end	1603	1625	1649	1660
index	0	1	2	3
commonw...	false	false	false	true
offset	0	1	0	0

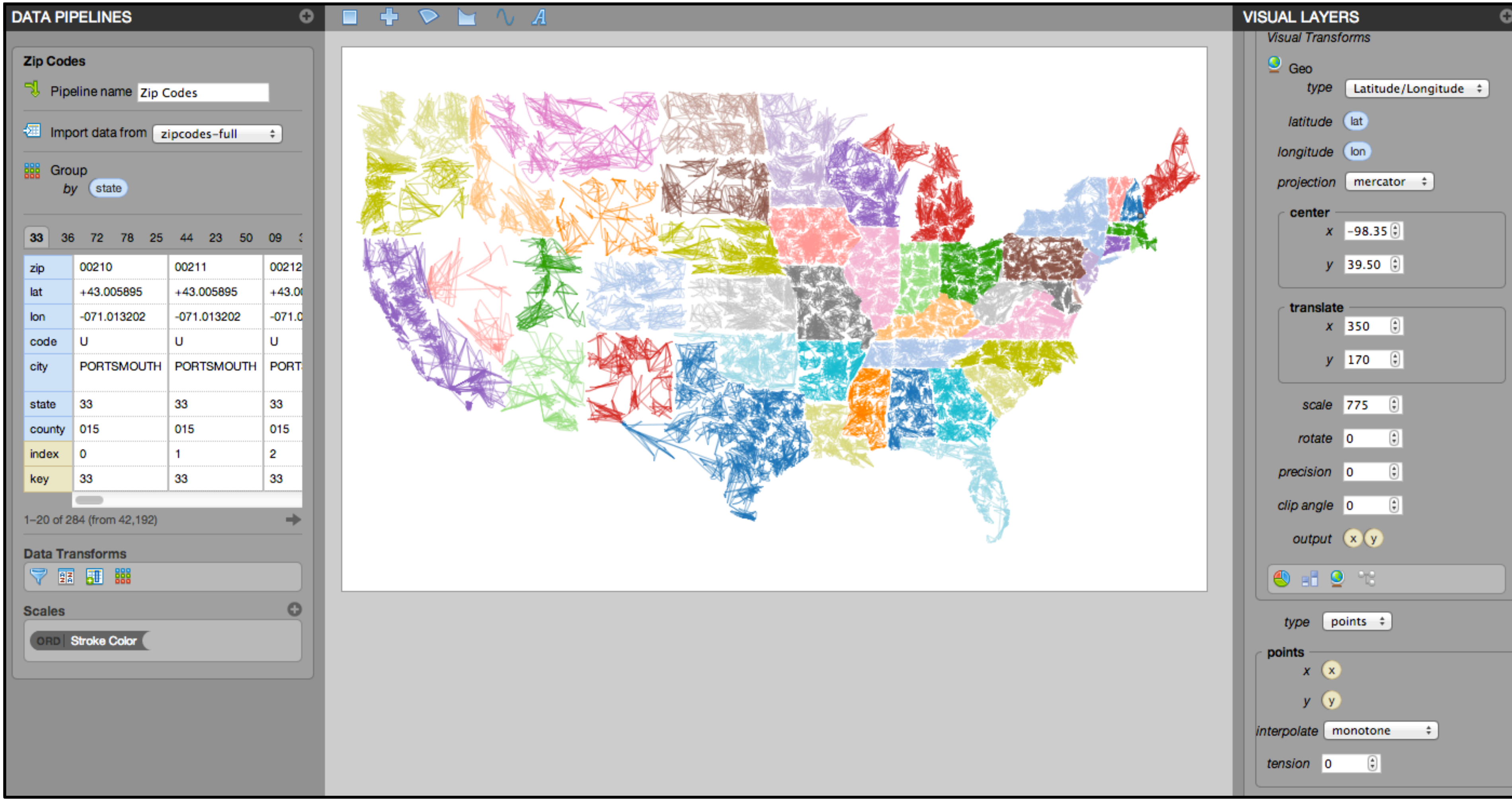
by William Playfair

Lyra A Visualization Design Environment



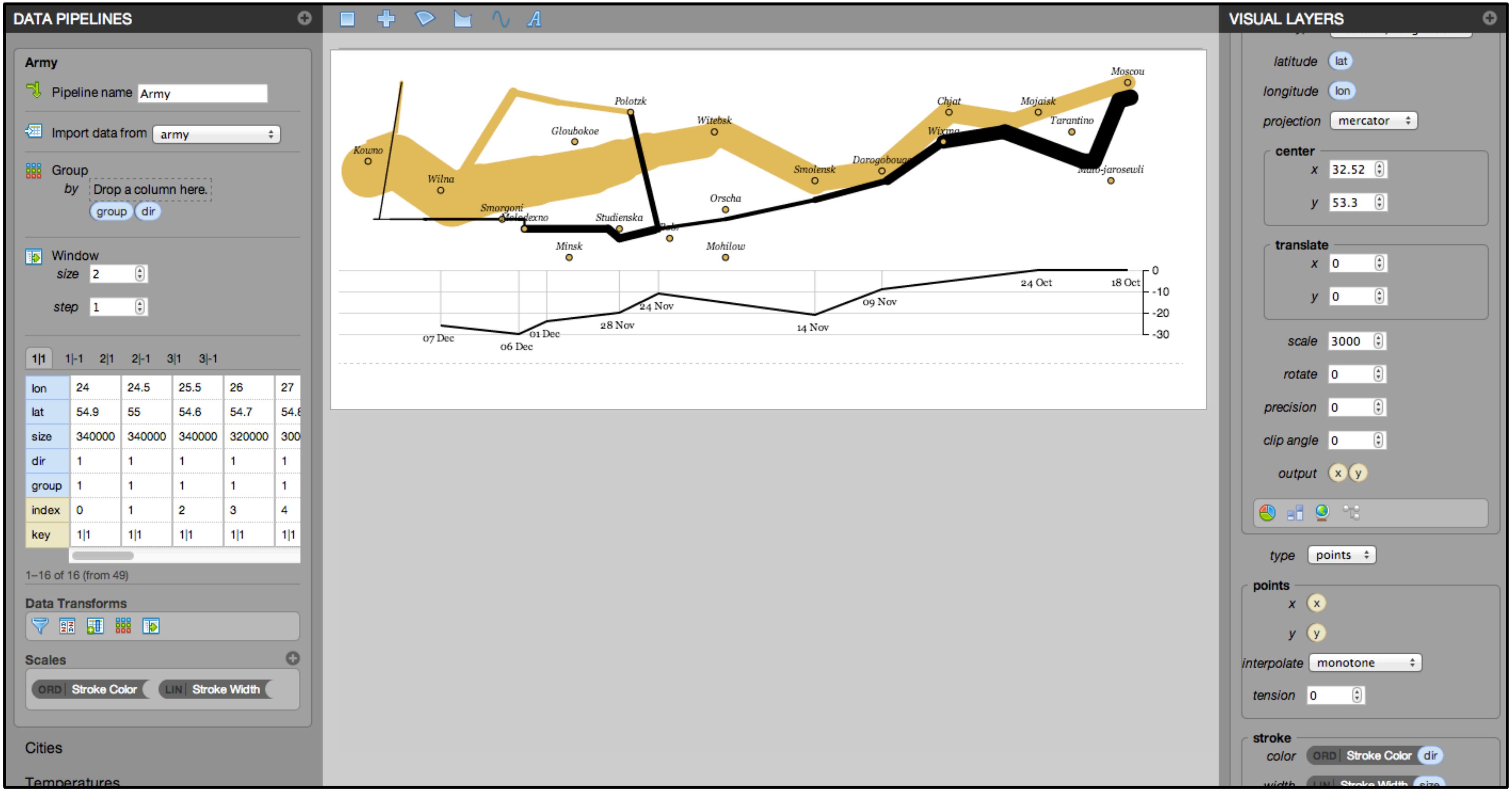
based on the **Railway Timetable** by E. J. Marey

Lyra A Visualization Design Environment

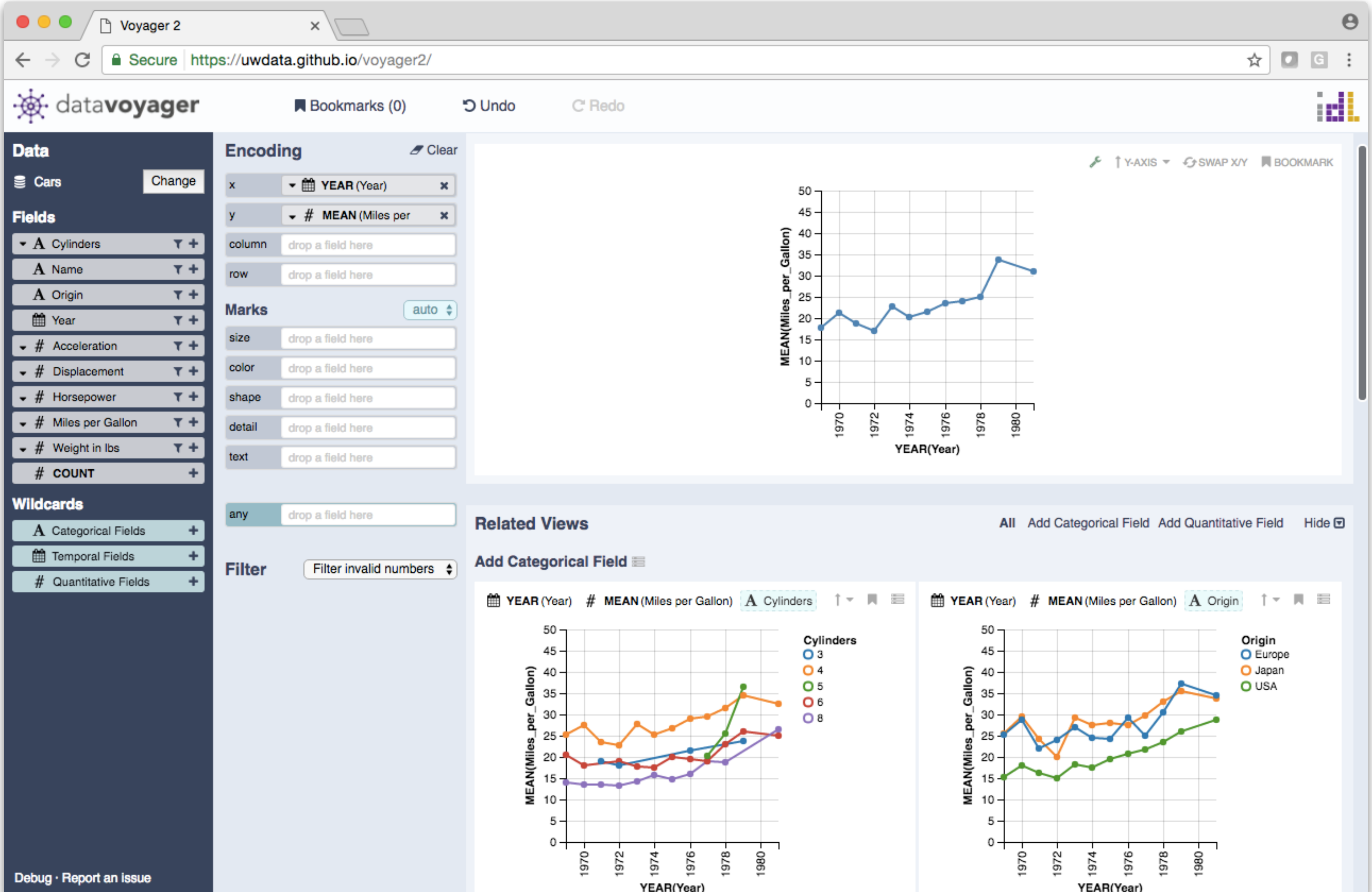


ZipScribble by Robert Kosara

Lyra A Visualization Design Environment



Napoleon's March by Charles Minard



Voyager. Wongsuphasawat et al. *InfoVis'15, CHI'17*

Key Idea: Augment manual exploration with visualization recommendations sensitive to the user's current focus.

The goal is to support *systematic consideration* of the data, without exacerbating *false discovery*.

To model a user's search frontier, we *enumerate related Vega-Lite specifications*, seeded by the user's current focus.

Candidate charts are pruned and ranked using models of estimated *perceptual effectiveness*.

Voyager. Wongsuphasawat et al. *InfoVis'15, CHI'17*

Interactive Data Exploration

Tableau, ***Lyra, Voyager***

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