



UNIVERSITY OF SAN FRANCISCO
CHANGE THE WORLD FROM HERE

Interactivity

INTRODUCTION



Data Analysis

“Data analysis, like experimentation, must be considered as an open-ended, **highly interactive, iterative process**, whose actual steps are selected segments of a stubbly branching, tree-like pattern of possible actions.”

The Collected Works of John W. Tukey, Volume IV Philosophy and Principles of Data Analysis: 1965-1986, by John W. Tukey, and David R. Cox



Types of Navigation

- Exploratory Navigation
- Directed Navigation



Types of Navigation

- **Exploratory Navigation**

- Explore data
- Find something interesting
- Ask a question...

- **Directed Navigation**

- Have a specific question
- Search for an answer
- Produce an answer



Discussion

Which type of navigation (**exploratory** vs **directed**) is information visualization well-suited for?



Observation and Spy Craft

- **Broad Awareness**

- Overview
- Awareness of abnormalities

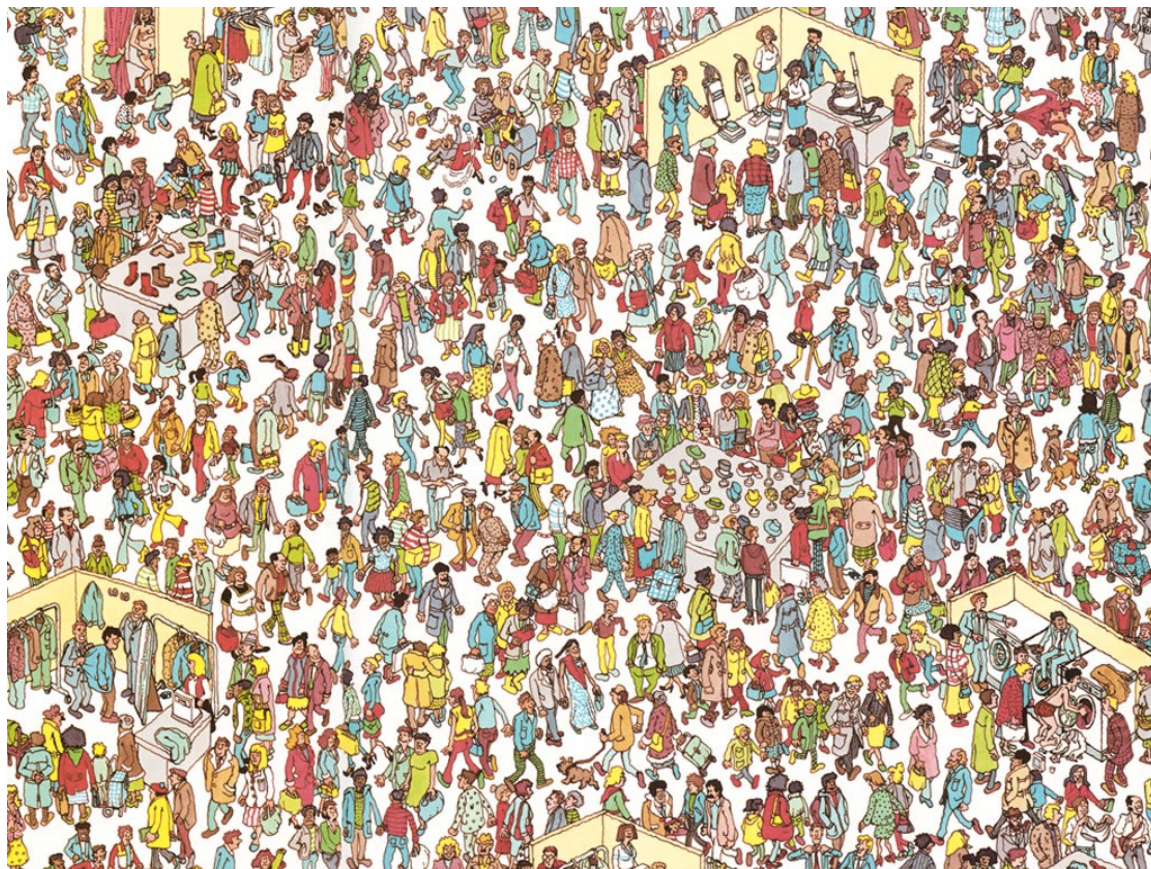
- **Close Observation and Analysis**

- Shift focus on abnormality
- Analyze abnormality

Shneiderman's Mantra



Readings in Information Visualization: Using Vision to Think
by Stuart K. Card, Jock D. Mackinlay, and Ben Shneiderman, Academic Press, San Diego, California, 1999, p625



<http://findwally.co.uk/fankit/graphics/IntlManOfLiterature/Scenes/DepartmentStore.jpg>

Shneiderman's Mantra

- **Overview**

- Reduces search time
- Allows detection of overall patterns
- Allows user to choose next move

- **Zoom and Filter**

- Iteratively narrow focus
- Remove extraneous information

- **Details On-Demand**

- Drill down to details



Types of Representations

- **Static Representations**
 - No Interactivity
- **Manipulable Representations**
 - Manipulate view of data
 - Actions include zoom, pan, rotate, etc.
- **Transformable Representations**
 - Manipulate input data
 - Actions include filter, average, etc.



Manipulable Representations

- **Exploration**
 - Zooming, rotation, scrolling/panning, sorting
- **Overview + Details**
 - Two separate views
- **Focus + Context**
 - One integrated view without occlusion
 - Focus shown in greater detail
 - Context shown in reduced detail



EXPLORATION

Manipulable Representations



Exploration

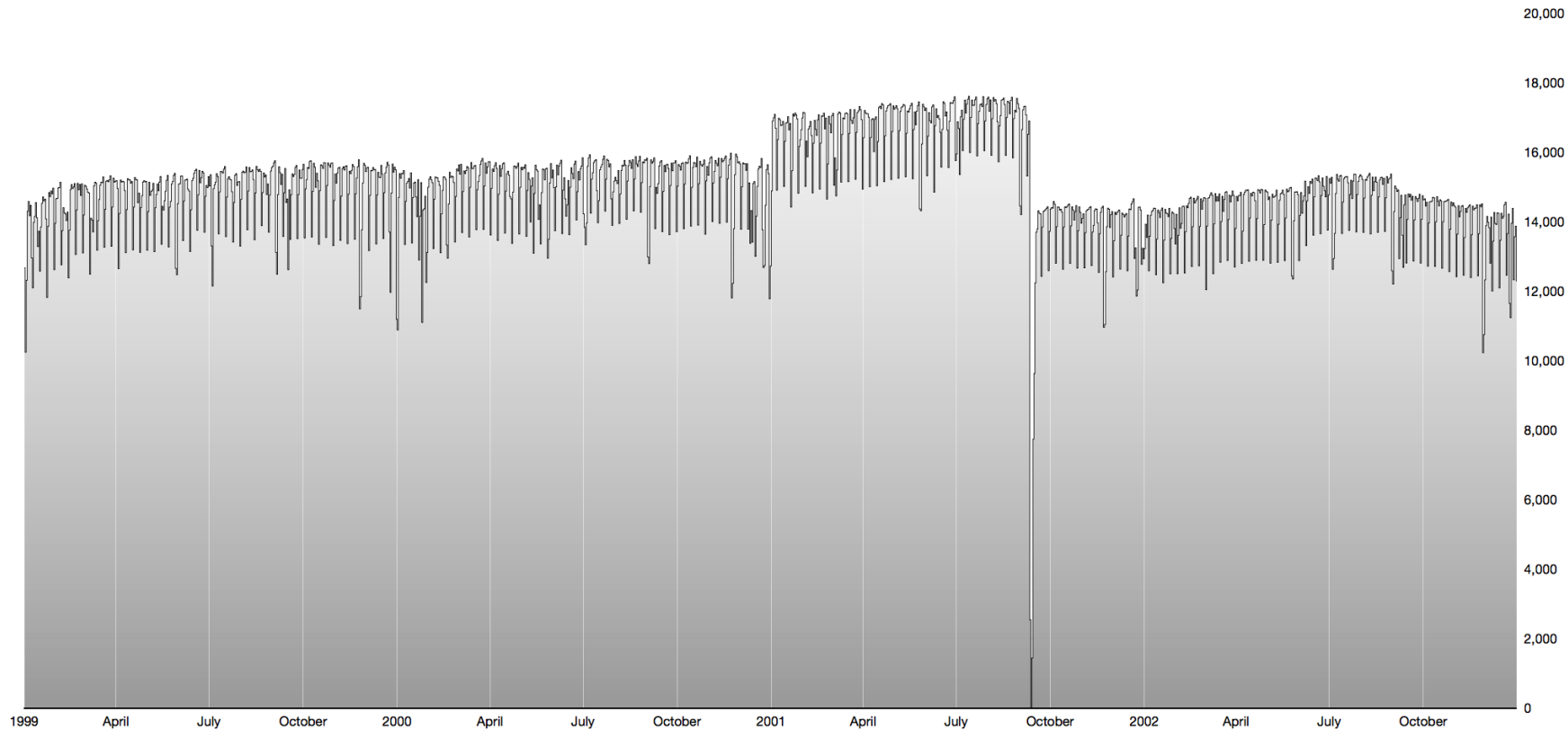
- **Operations**

- Zooming, panning or scrolling, rotating, and more

- **Considerations**

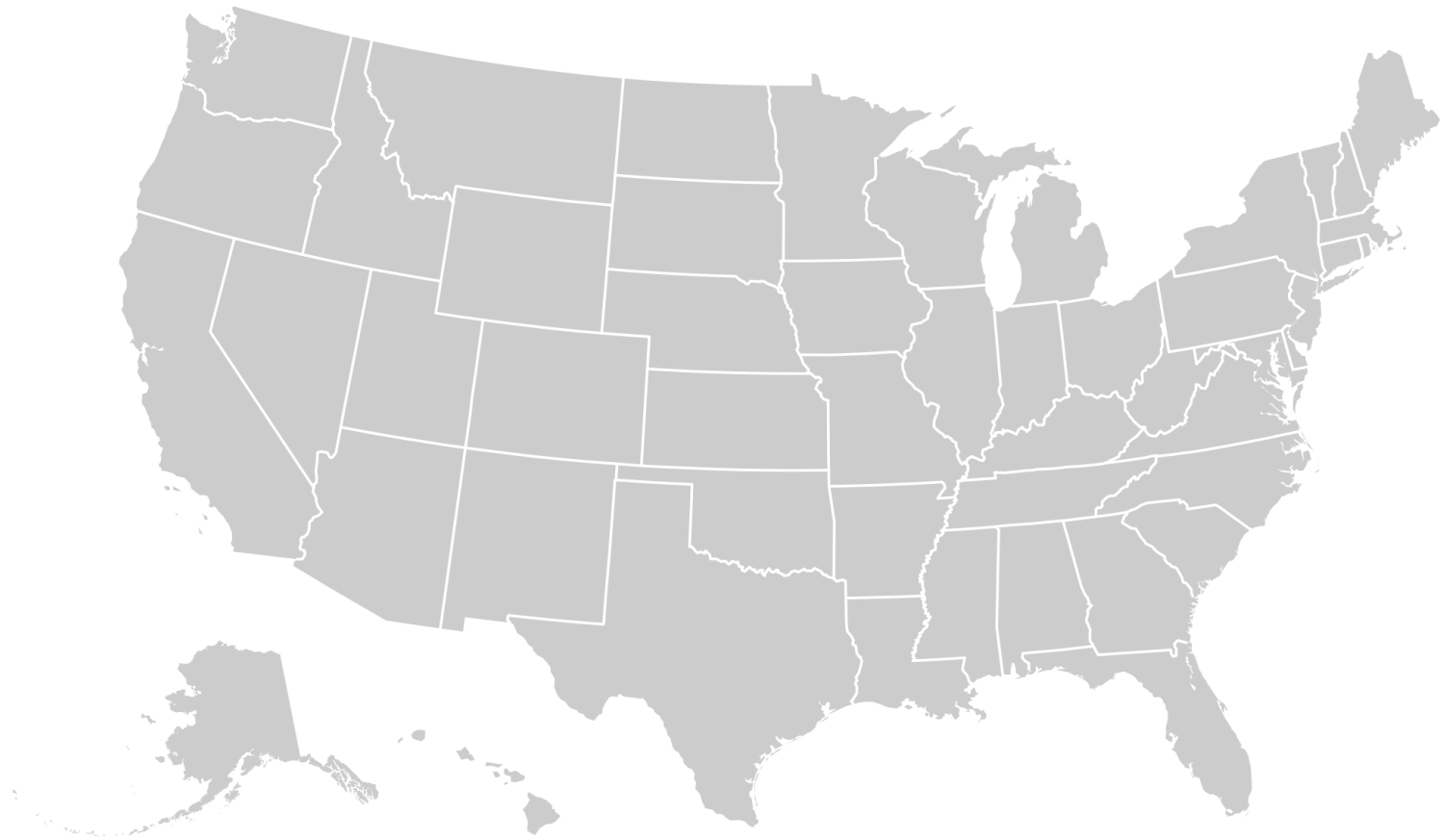
- Avoid blinking (change blindness)
- Keep transitions smooth to maintain context



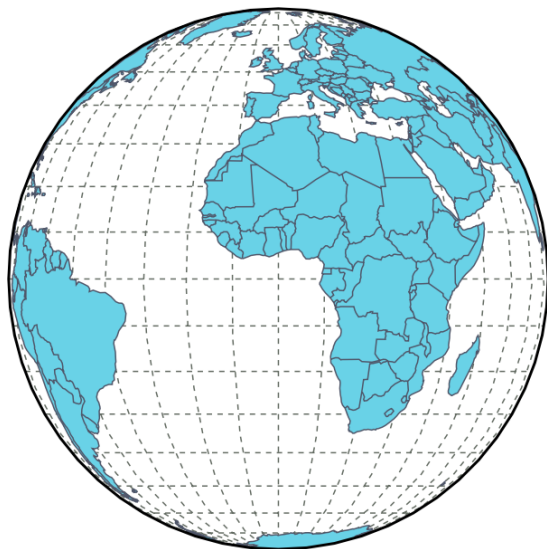


<http://mbostock.github.io/d3/talk/20111018/area-gradient.html>

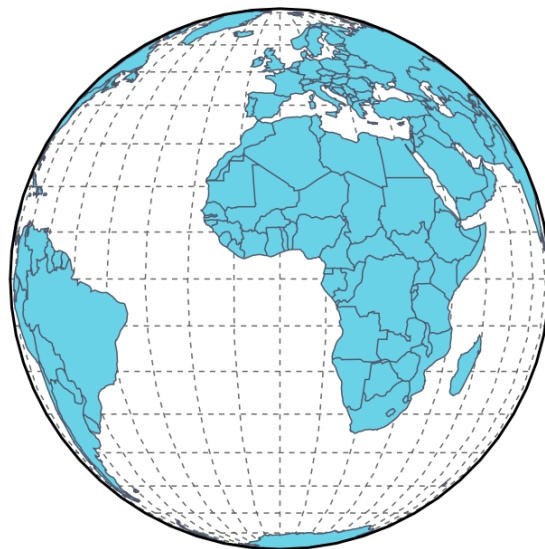




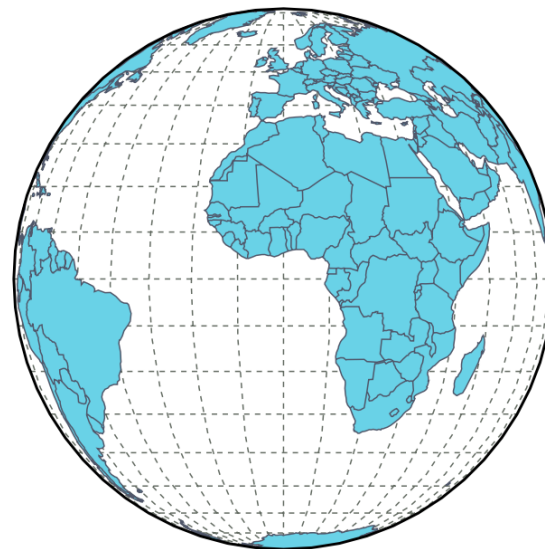
<http://bl.ocks.org/mbostock/9656675>



$$\lambda=0^\circ$$



$$\varphi=0^\circ$$



$$\gamma=0^\circ$$

<https://www.jasondavies.com/maps/rotate/>



<http://mbostock.github.io/d3/talk/20111018/treemap.html>

OVERVIEW + DETAIL

Manipulable Representations



Overview + Detail

- **Overview View**

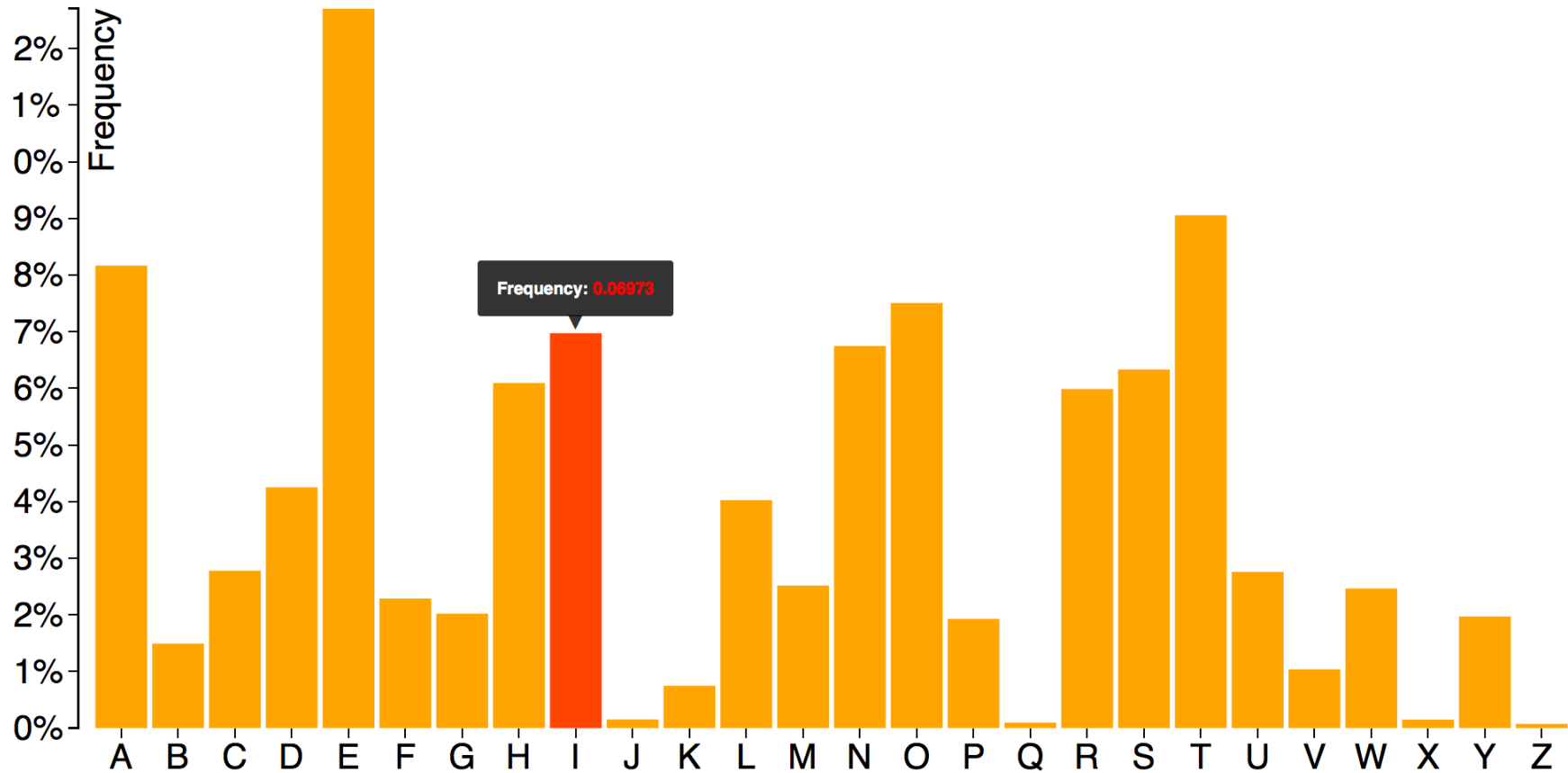
- Use for navigation or search tasks
- Avoid cluttering overview with too much detail

- **Detail View**

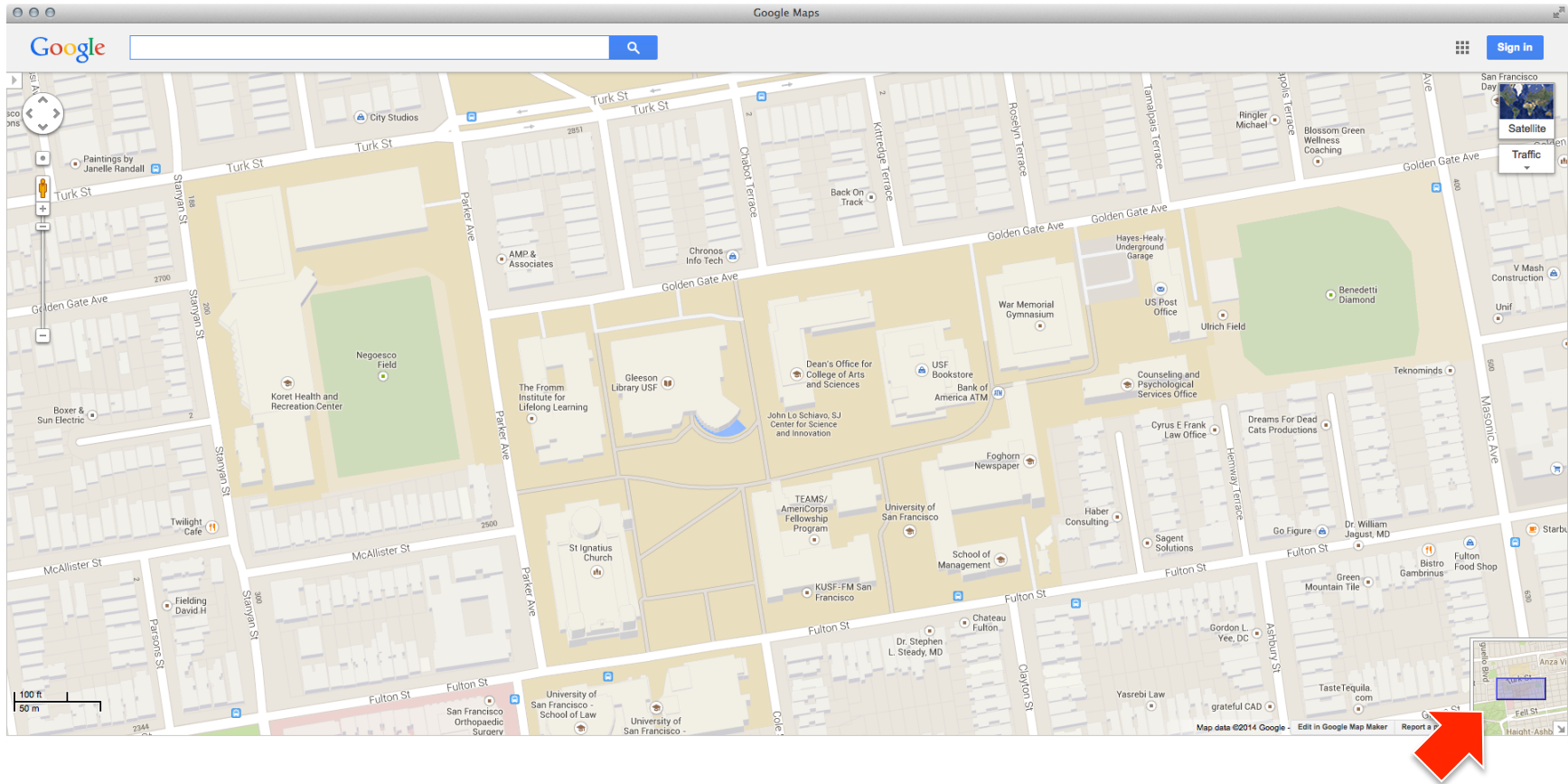
- Shows additional information
- Data selected from overview

<http://www.infovis-wiki.net/index.php?title=Overview-plus-Detail>





<http://bl.ocks.org/Caged/6476579>



<https://www.google.com/maps?t=m&ll=37.777635,-122.445502&z=16&output=classic&dg=opt>



Interactivity.pptx

Search in Presentation

20

Overview + Detail

- **Overview View**
 - Use for navigation or search tasks
 - Avoid cluttering overview with too much detail
- **Detail View**
 - Shows additional information
 - Data selected from overview

<http://www.infovis-wiki.net/index.php?title=Overview-plus-Detail>

Interactivity
Last Updated March 30, 2014

Sophie Engle
sengl@cs.usfca.edu

UNIVERSITY OF
SAN FRANCISCO

Click to add notes

Slide 20 of 56 216%

Microsoft Powerpoint

The image shows a Sublime Text editor window with two tabs: `IndexTest.java` and `SearchTest.java`. The left sidebar displays a file explorer for a project named "Search Engine".

IndexTest.java

```

65
66
67 public void testNoOutput() throws IOException {
68     String base = ProjectTest.getBaseDirectory();
69     Path input = Paths.get(base, "input", "index", "simple");
70     Path output = Paths.get("index.txt");
71
72     String[] args = {
73         "-d", input.toAbsolutePath().normalize().toString();
74     };
75
76     Files.deleteIfExists(output);
77     ProjectTest.checkExceptions("No Output", args);
78
79     String errorMessage = String.format(
80         "%n" + "Test Case: %s%n" + "%s%n",
81         "No Output",
82         "Do not create index.txt unless proper flag provided");
83
84     Assert.assertFalse(errorMessage, Files.isReadable(output));
85 }
86
87 public static class IndexOutputTest {
88
89     @Test
90     public void testIndexSimple() {
91         String base = ProjectTest.getBaseDirectory();
92         String name = "index-simple.txt";
93
94         Path input = Paths.get(base, "input", "index", "simple");
95         Path output = Paths.get(base, "output", name);
96         Path result = Paths.get("result", name);
97
98         String[] args = new String[] {
99             "-d", input.toAbsolutePath().normalize().toString(),
100             "-i", result.toAbsolutePath().normalize().toString()
101         };
102     }
103 }

```

SearchTest.java

```

106 /**
107  * Tests whether program fails gracefully when attempt to write
108  * a directory instead of a file path.
109  */
110 @Test
111 public void testNowWriteDirectory() {
112     String base = ProjectTest.getBaseDirectory();
113     Path input = Paths.get(base, "input", "index", "simple");
114     Path query = Paths.get(base, "input", "queries", "simple");
115
116     try {
117         Path path = Files.createTempDirectory(Paths.get(".").toAbsolutePath().normalize().toString());
118         path.toFile().deleteOnExit();
119
120         String[] args = new String[] {
121             "-d", input.toAbsolutePath().toString(),
122             "-q", query.toAbsolutePath().toString(),
123             "-r", path.toAbsolutePath().toString();
124         };
125
126         Driver.main(args);
127     } catch (Exception e) {
128         StringWriter writer = new StringWriter();
129         e.printStackTrace(new PrintWriter(writer));
130
131         Assert.fail(String.format(
132             "%n" + "Test Case: %s%n" + "Exception: %s%n",
133             "No Write Directory", writer.toString()));
134     }
135 }
136
137 public static class SearchOutputTest {
138
139     @Test
140     public void testSearchSimple() {
141

```

At the bottom of the editor, a status bar shows "Line 1, Column 1", "28 misspelled words", "Tab Size: 4", and "Java".

Sublime Text 2 • <http://www.sublimetext.com/>



FOCUS + CONTEXT

Manipulable Representations



Focus + Context

- **Fisheye Distortion**
 - Center of distortion provides **focus**, surrounding area provides **context**
- **Brushing**
 - Highlighted (brushed) data provides **focus**, greyed-out data provides **context**
- **Linked Views**
 - Highlighted data provides **focus**, multiple linked views provides **context**

<http://www.infovis-wiki.net/index.php/Focus-plus-Context>



Fisheye Distortion

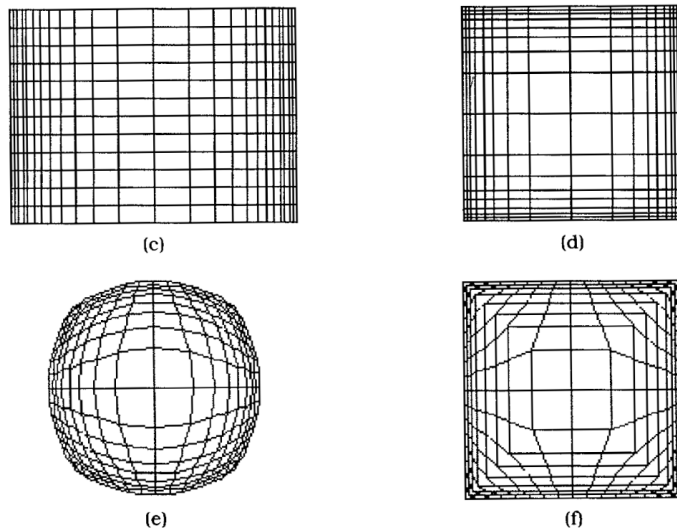
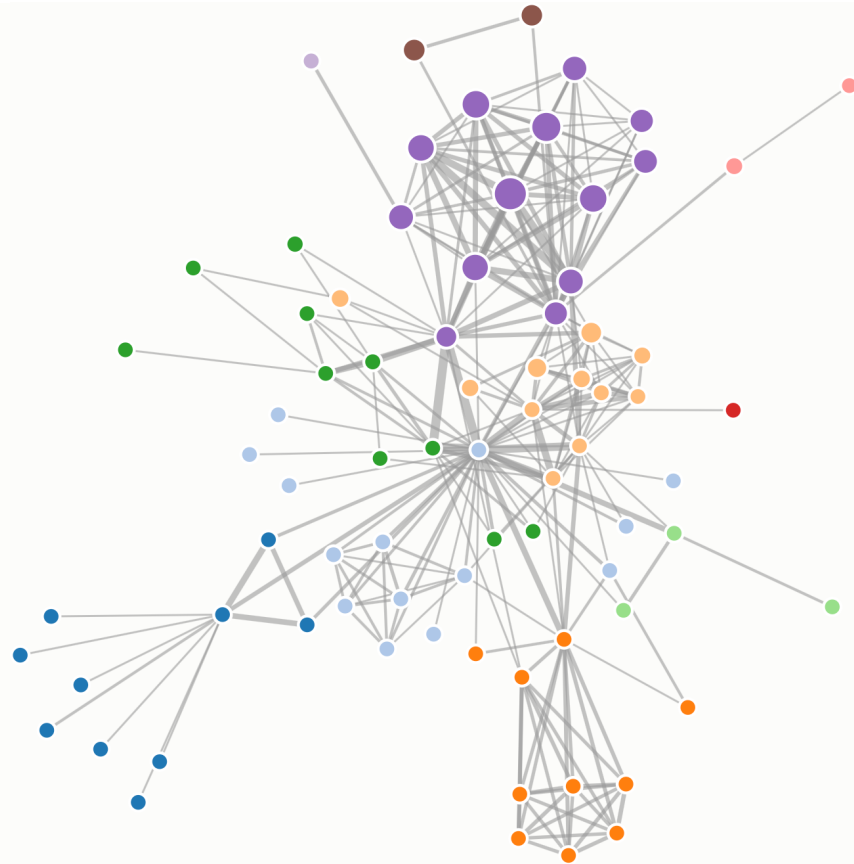


Fig. 11. The Fisheye View: (a) a typical transformation function; (b) the corresponding magnification function; (c) the application of the Fisheye View in one dimension; (d) a Cartesian Fisheye View in two dimensions; (e) a polar Fisheye View; (f) a normalized polar Fisheye View.



“A Review and Taxonomy of Distortion-Oriented Presentation Techniques” by Y. K. Leung and M. D. Apperley

http://en.wikipedia.org/wiki/Fisheye_lens



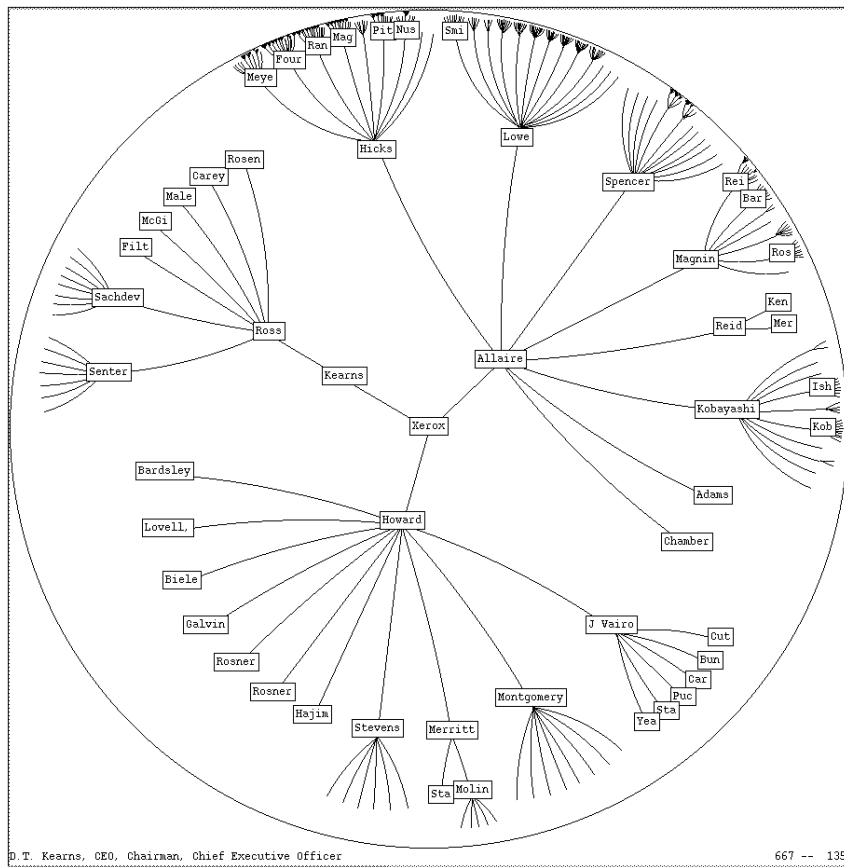
<http://bost.ocks.org/mike/fisheye/>

Hyperbolic Trees

- Components diminish in size as move outwards
 - Uses fisheye distortion
- Focus changed by clicking a node
 - Node moves to center and increases in size
 - Other nodes move to edges and decrease in size
- Allows display of large hierarchical trees without loss of focus and context

http://www.sigchi.org/chi95/Electronic/documnts/papers/jl_bdy.htm





http://www.sigchi.org/chi95/Electronic/documnts/papers/jl_bdy.htm

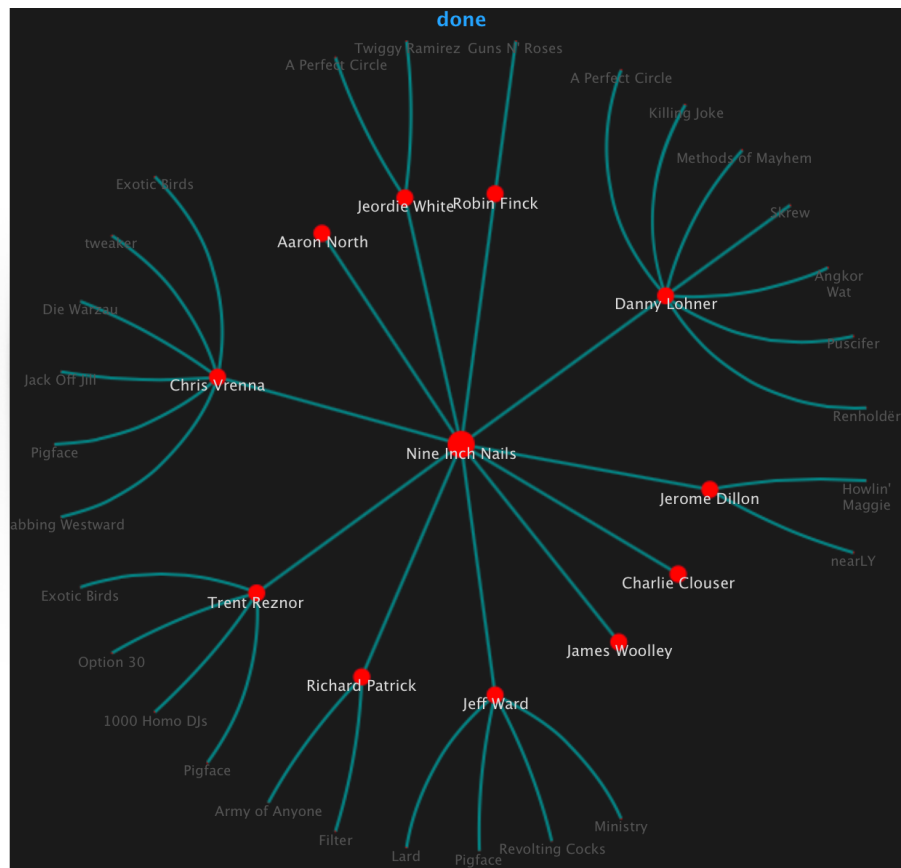
Tree Animation

A static JSON Tree structure is used as input for this animation.

Clicking on a node should move the tree and center that node.

The centered node's children are displayed in a relations list in the right column.

[See the Example Code](#)



Nine Inch Nails

Connections:

- Jerome Dillon (relation: member of band)
- Charlie Clouser (relation: member of band)
- James Woolley (relation: member of band)
- Jeff Ward (relation: member of band)
- Richard Patrick (relation: member of band)
- Trent Reznor (relation: member of band)
- Chris Vrenna (relation: member of band)
- Aaron North (relation: member of band)
- Jeordie White (relation: member of band)
- Robin Finck (relation: member of band)
- Danny Lohner (relation: member of band)

<http://philogb.github.io/jit/static/v20/Jit/Examples/Hypertree/example1.html>

Brushing and Linked Views

- **Brushing**

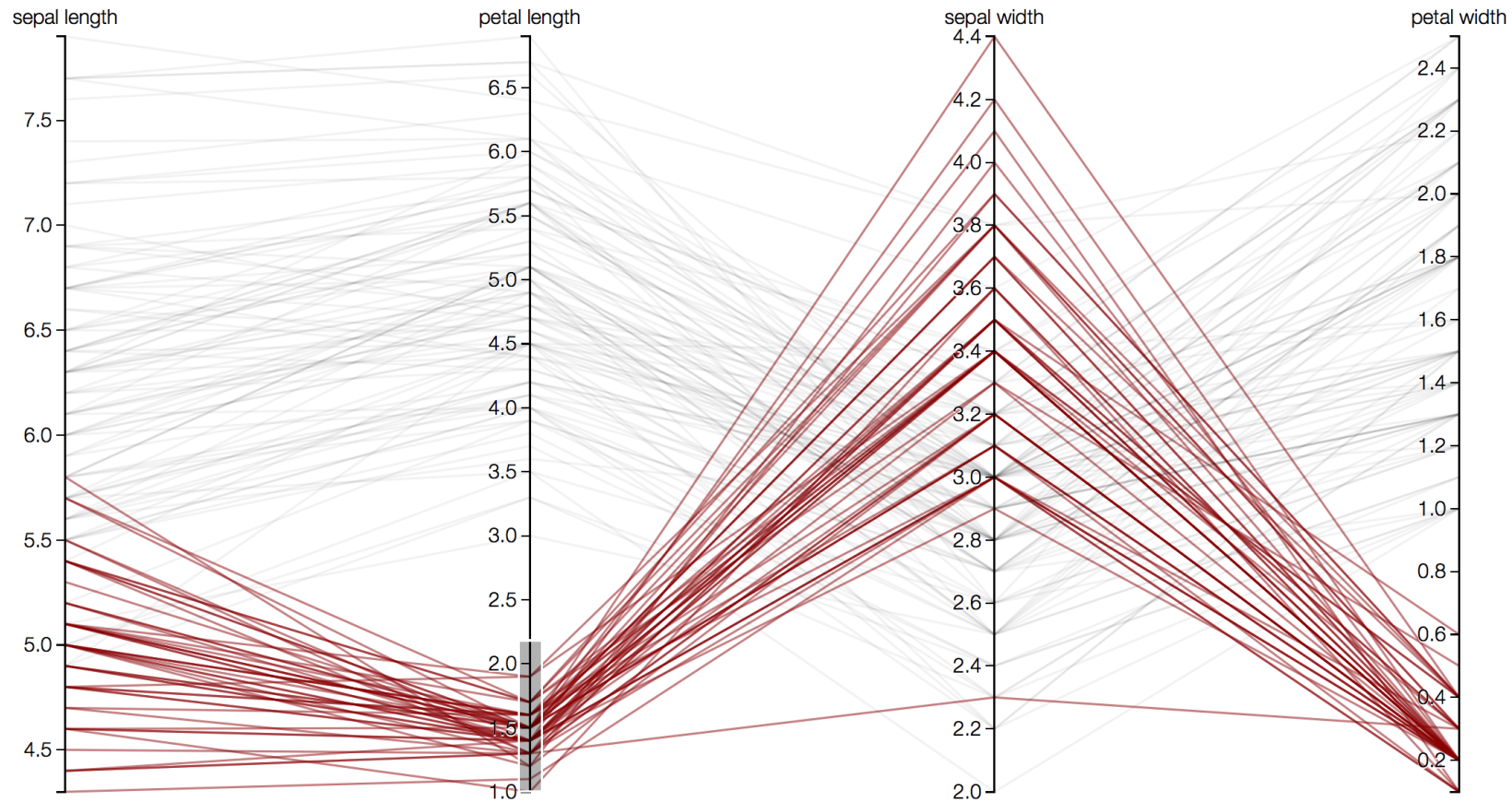
- Emphasize specific data points (bring to foreground)
- De-emphasize other data points (bring to background)

- **Linked Views**

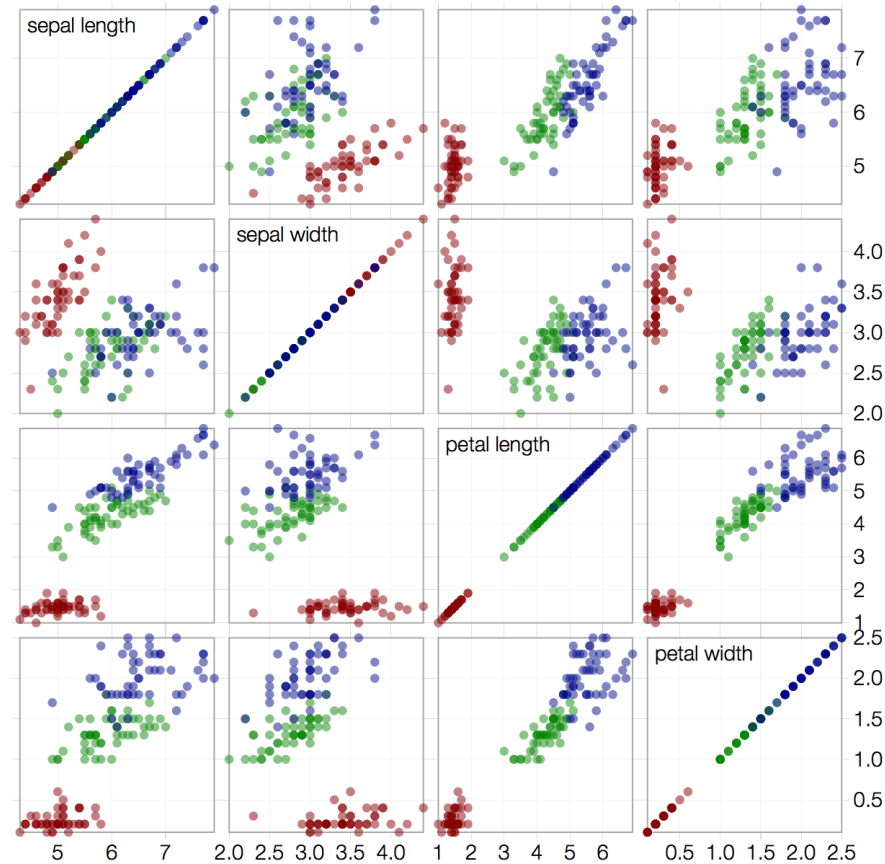
- Often combined with brushing
- Show highlighted data across multiple different views of the data for more context

http://www.infovis-wiki.net/index.php?title=Linking_and_Brushing

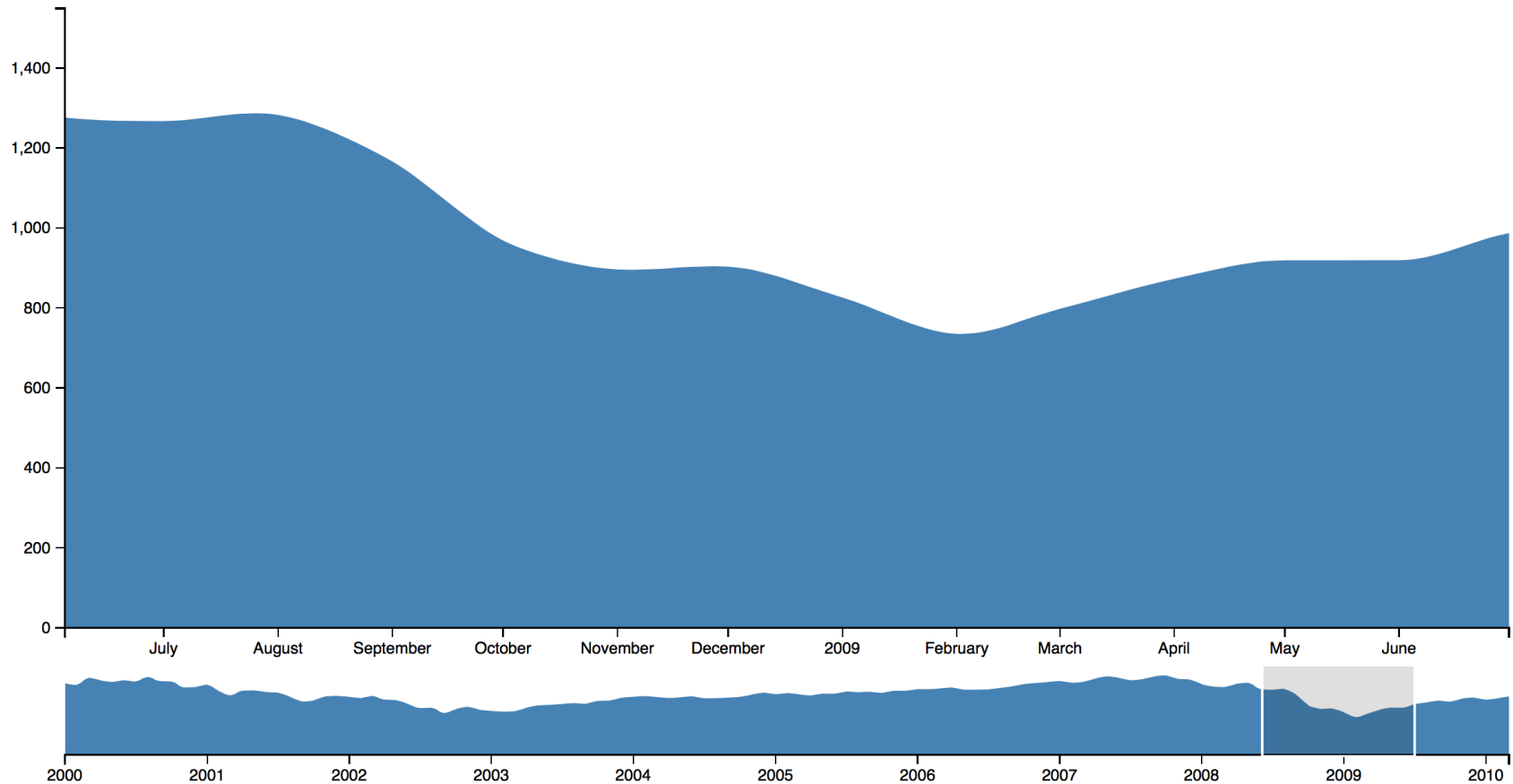




<http://mbostock.github.com/d3/talk/20111116/iris-parallel.html>



<http://mbostock.github.io/d3/talk/20111116/iris-splom.html>



<http://bl.ocks.org/mbostock/1667367>

DATA TRANSFORMATIONS

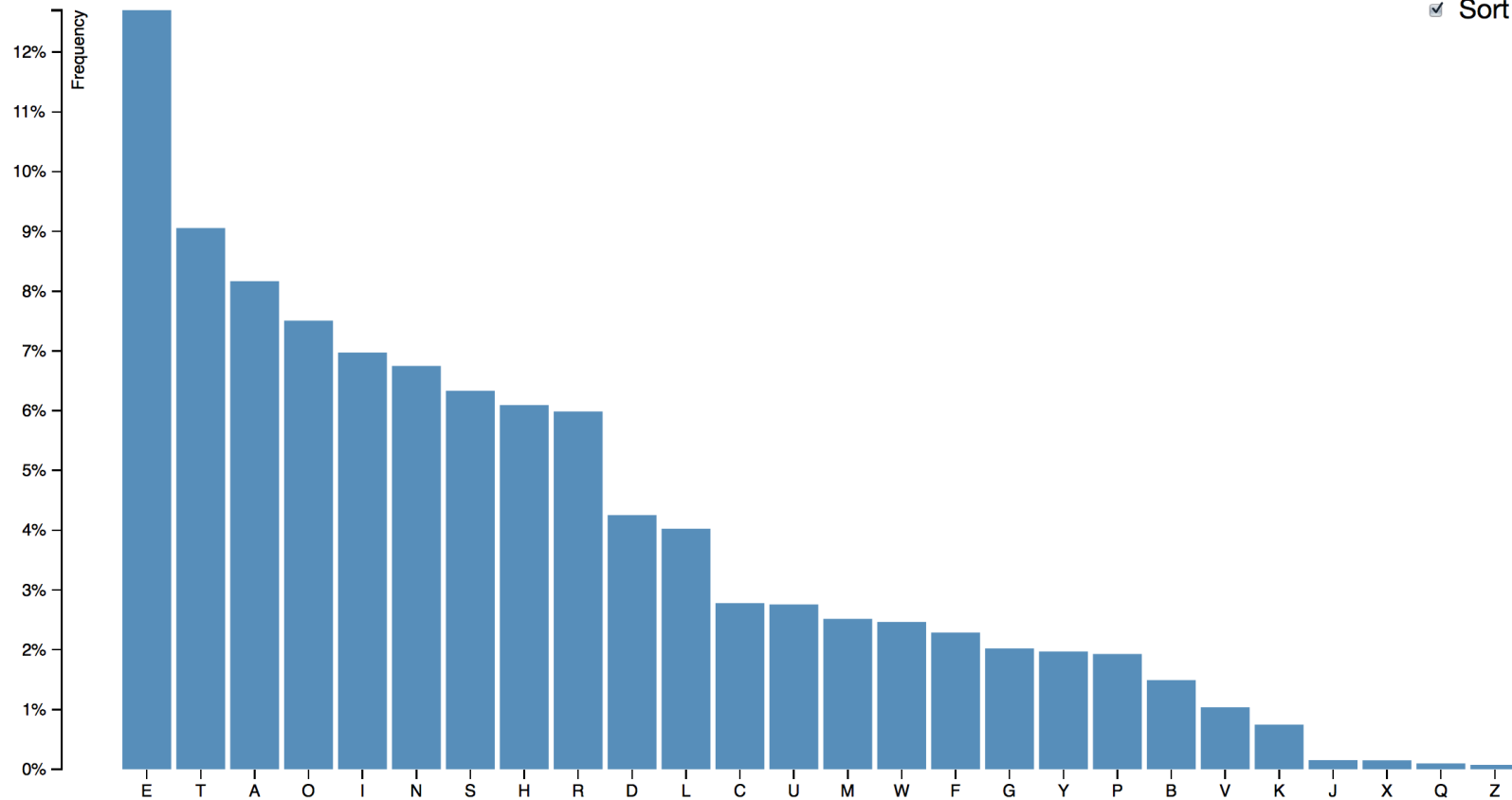
Transformable Representations



Transformable Representations

- Transform **underlying dataset** in some way
 - Sorting, filtering, clustering, drill down, *and more...*
- Visualizations can be both **transformable** and **manipulable**

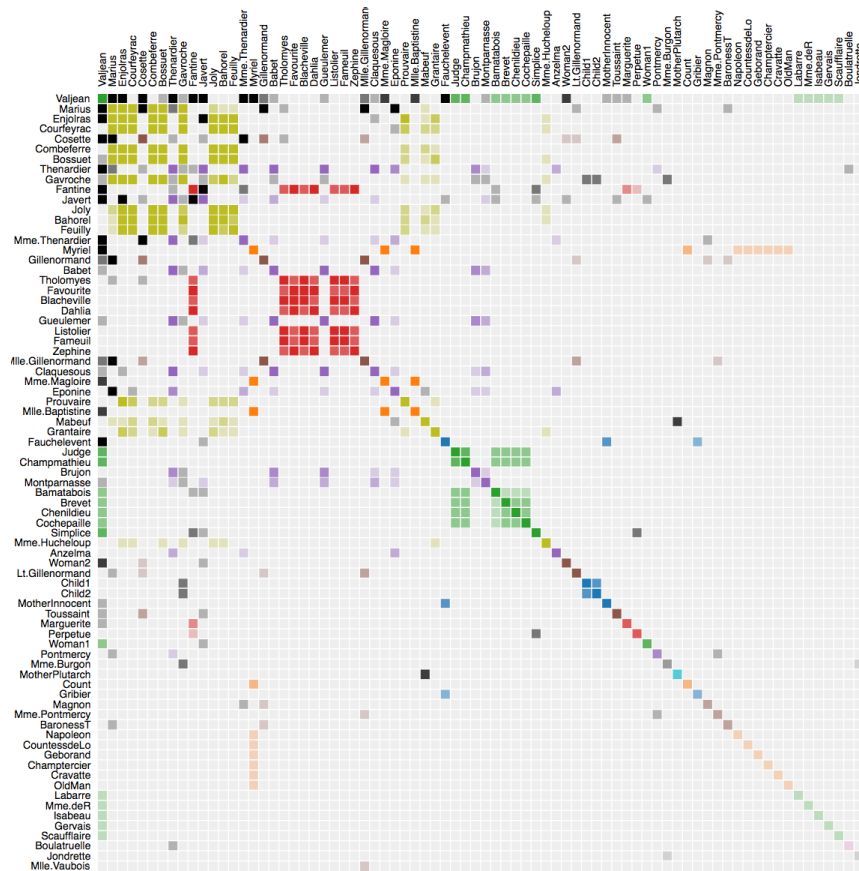




<http://bl.ocks.org/mbostock/3885705>

State	Monthly premiums for a family of four with an income of ... ▲		A 27-year-old individual who makes ...	
	... more than \$94,200 a year, ineligible for subsidies	\$50,000 a year and getting subsidies	... more than \$45,960 a year	\$25,000 a year and getting subsidies
Average, 36 States	\$774	\$282	\$214	\$145
Tennessee	584	282	161	145
Arizona	600	282	166	145
Kansas	619	282	171	145
Oklahoma	634	282	175	145
Utah	656	282	203	145
New Mexico	672	282	186	145
Pennsylvania	675	282	187	145
Idaho	680	282	188	145
Illinois	682	282	188	145
Iowa	683	282	189	145
Texas	727	282	201	145
Michigan	731	282	202	145
Nebraska	744	282	206	145
Montana	753	282	208	145
Alabama	757	282	209	145
Ohio	768	282	212	145
Florida	789	282	218	145
West Virginia	789	282	218	145
Missouri	798	282	220	145
Virginia	799	282	221	145
Georgia	800	282	221	145
South Carolina	809	282	223	145
North Dakota	841	282	232	145
South Dakota	852	282	235	145

<http://www.nytimes.com/interactive/2013/09/24/us/health-care-premiums.html>



Order:

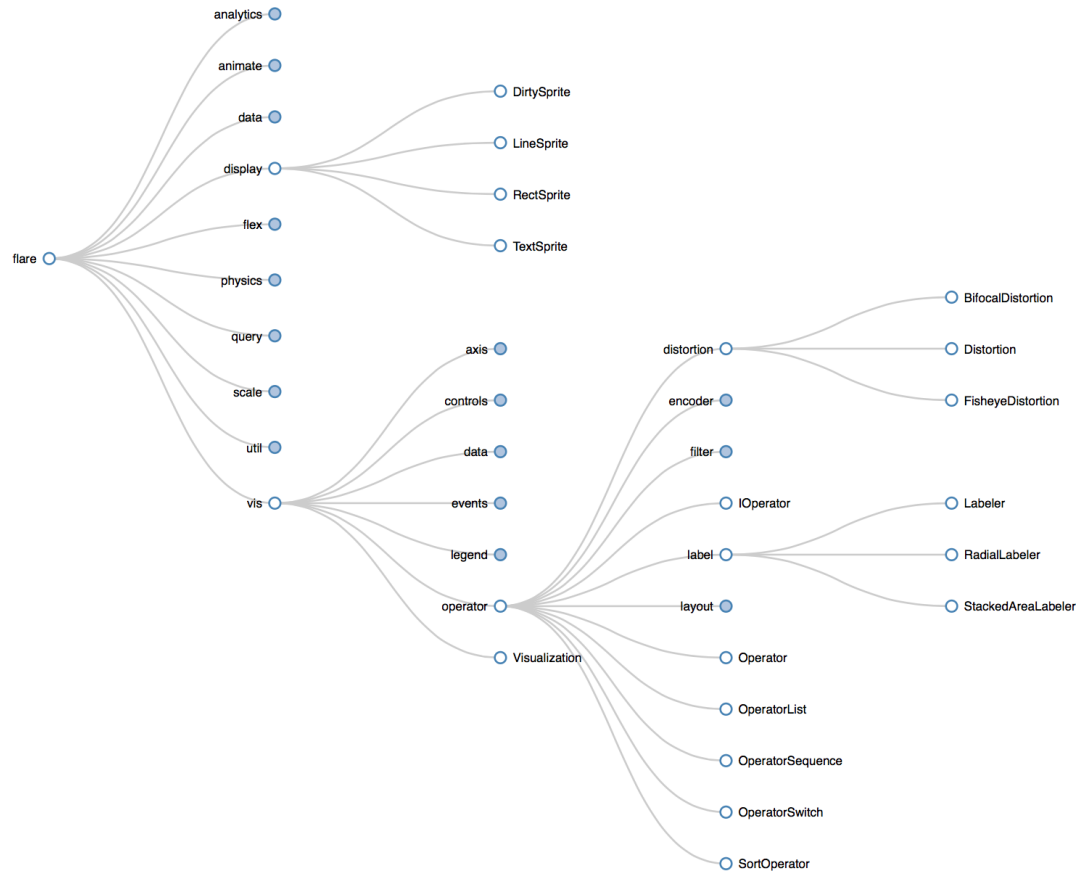
This matrix diagram visualizes character co-occurrences in Victor Hugo's *Les Misérables*.

Each colored cell represents two characters that appeared in the same chapter; darker cells indicate characters that co-occurred more frequently.

Use the drop-down menu to reorder the matrix and explore the data.

Built with [d3.js](#).

<http://bost.ocks.org/mike/miserables/>



<http://bl.ocks.org/mbostock/4339083>

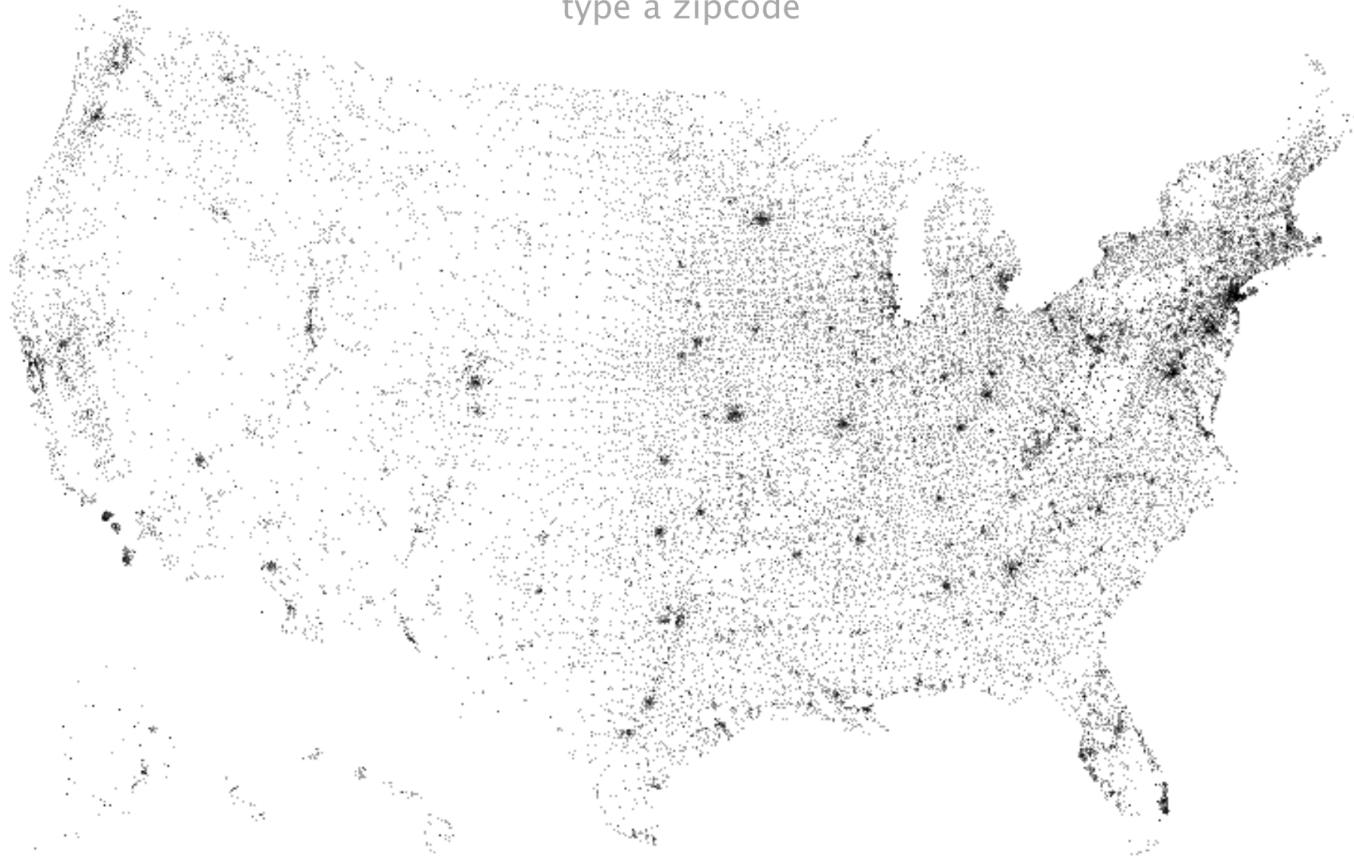
EXAMPLES

Data: Drill Down, Filtering, Sorting

View: Overview + Detail, Focus + Context



type a zipcode



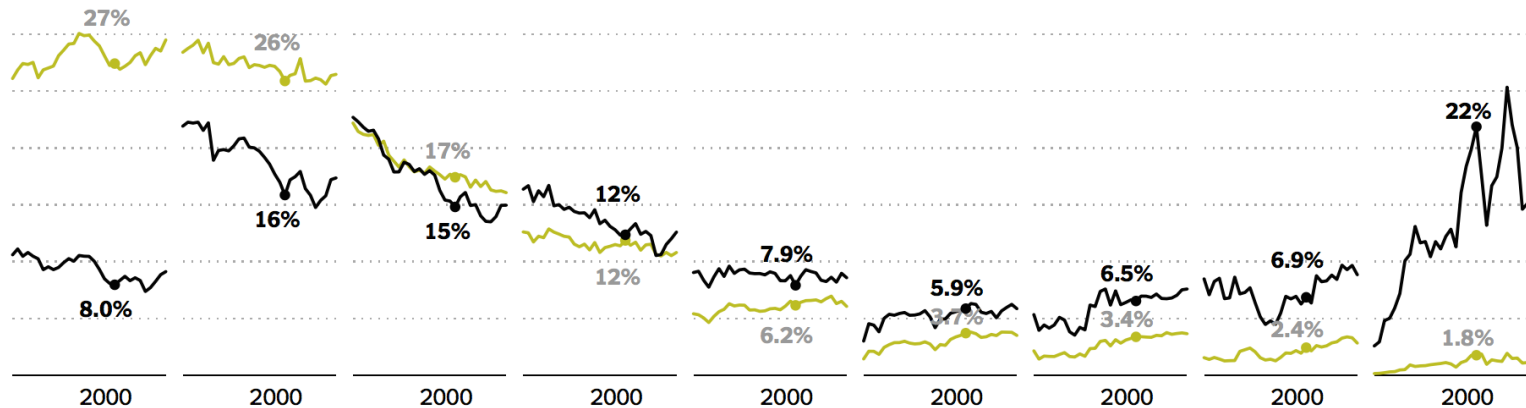
<http://bl.ocks.org/mbostock/5180185>





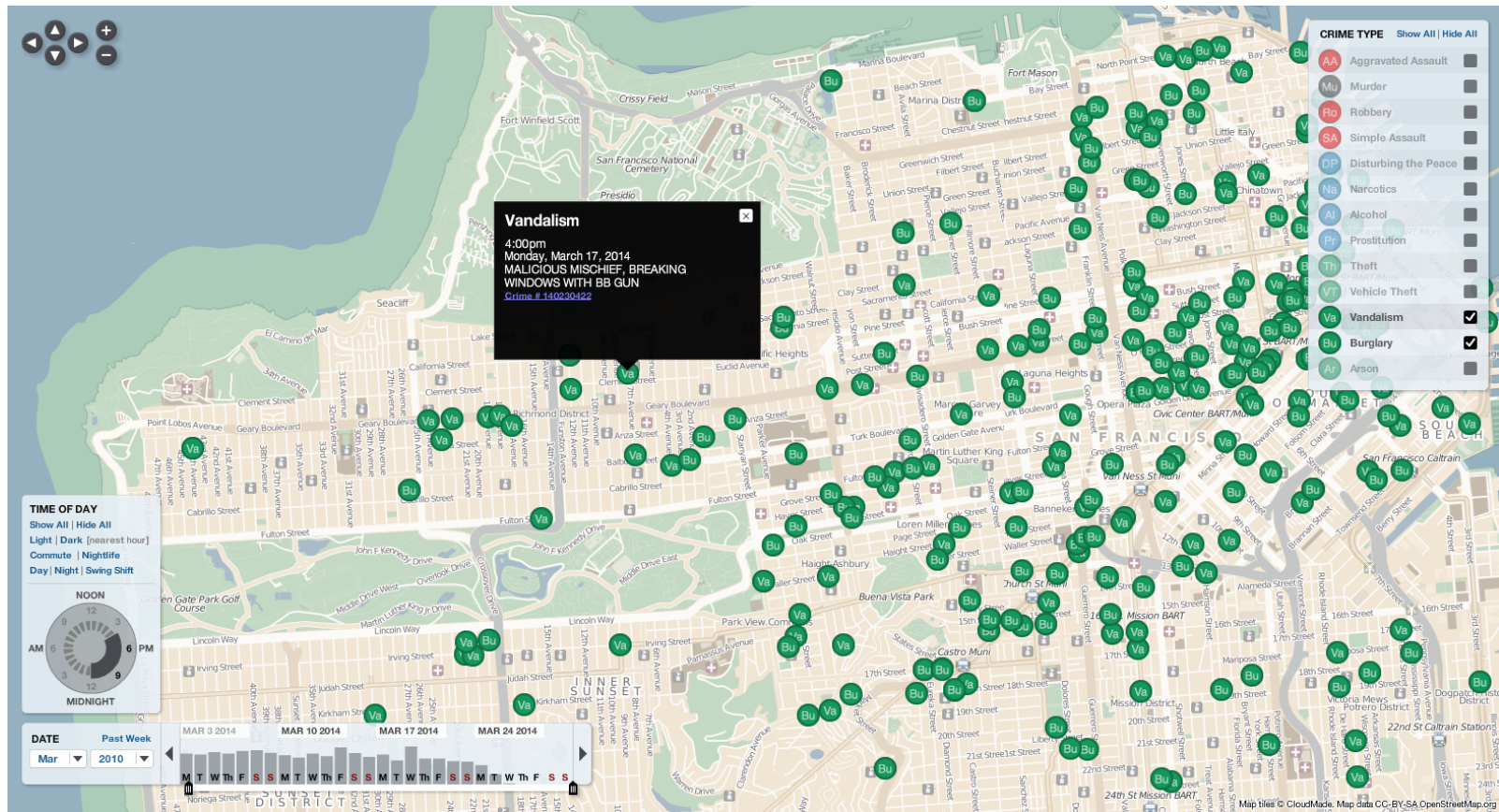
Affluent households are earning more — and paying a larger share of taxes.

For each income bracket, its share of nation's — income and — population.

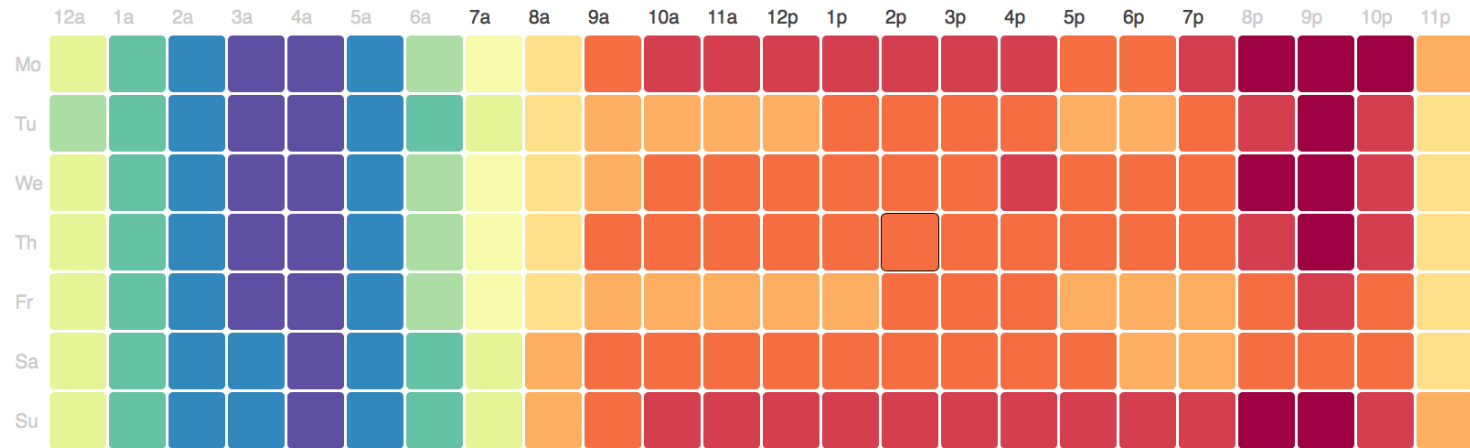


The number of high-income households, and their average income, has increased rapidly. Even in the wake of the recession, more than a million taxpayers made at least \$350,000 in 2010, and that group accounted for 15 percent of the nation's income. As a result, while those households paid a smaller share of their income in taxes than they did in 1980, they paid a larger share of the total tax bill.

<http://www.nytimes.com/interactive/2012/11/30/us/tax-burden.html>



<http://sanfrancisco.crimespotting.org>



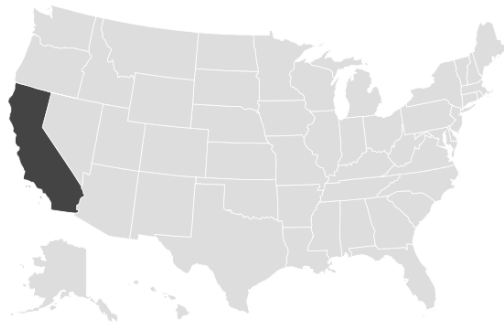
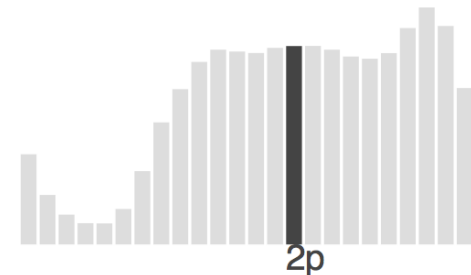
All Traffic

Computer

Mobile

All States

California

powered by
trulia86%
Computer14%
Mobile

All traffic on Thursdays

<http://www.trulia.com/trends/vis/tru247/>

Baby Name > ☐ Both ☐ Boys ☒ Girls

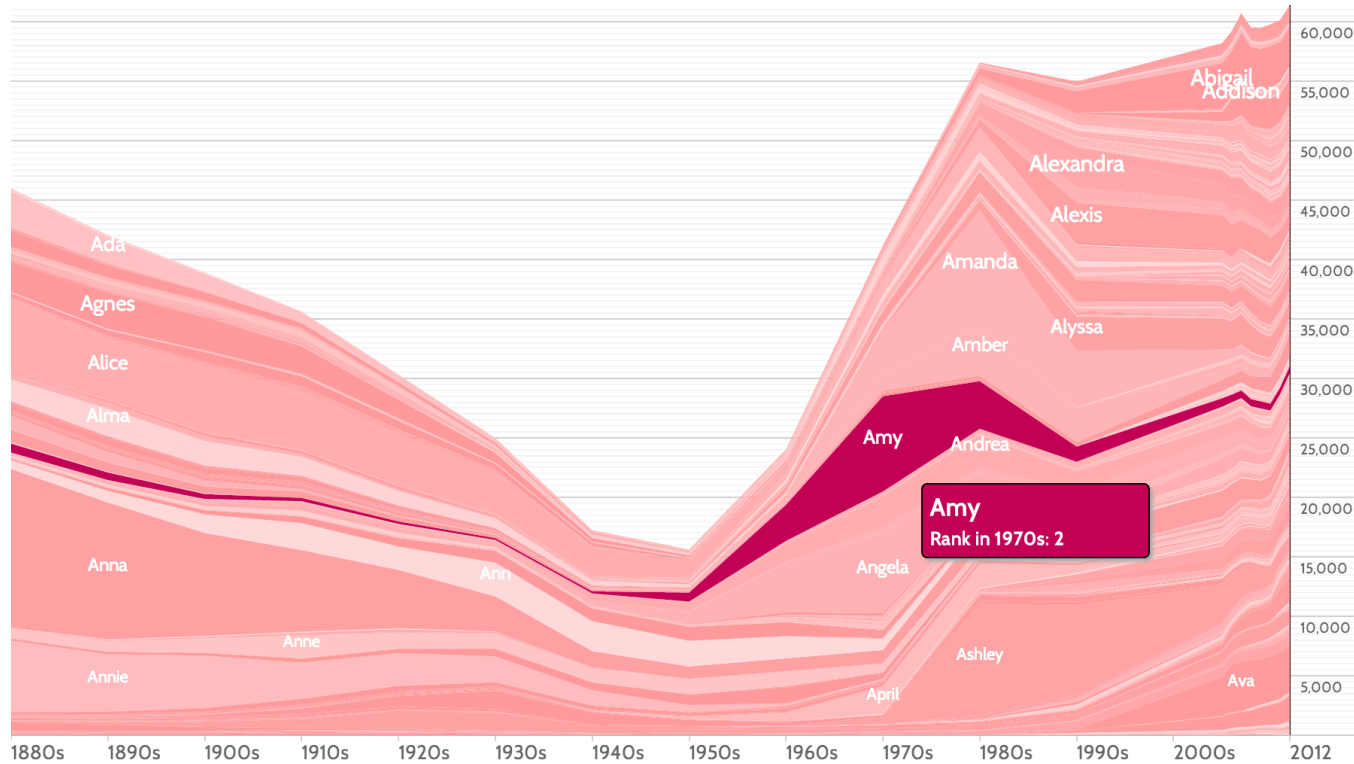
Current rank: boys

1000	500	100	25	1
------	-----	-----	----	---

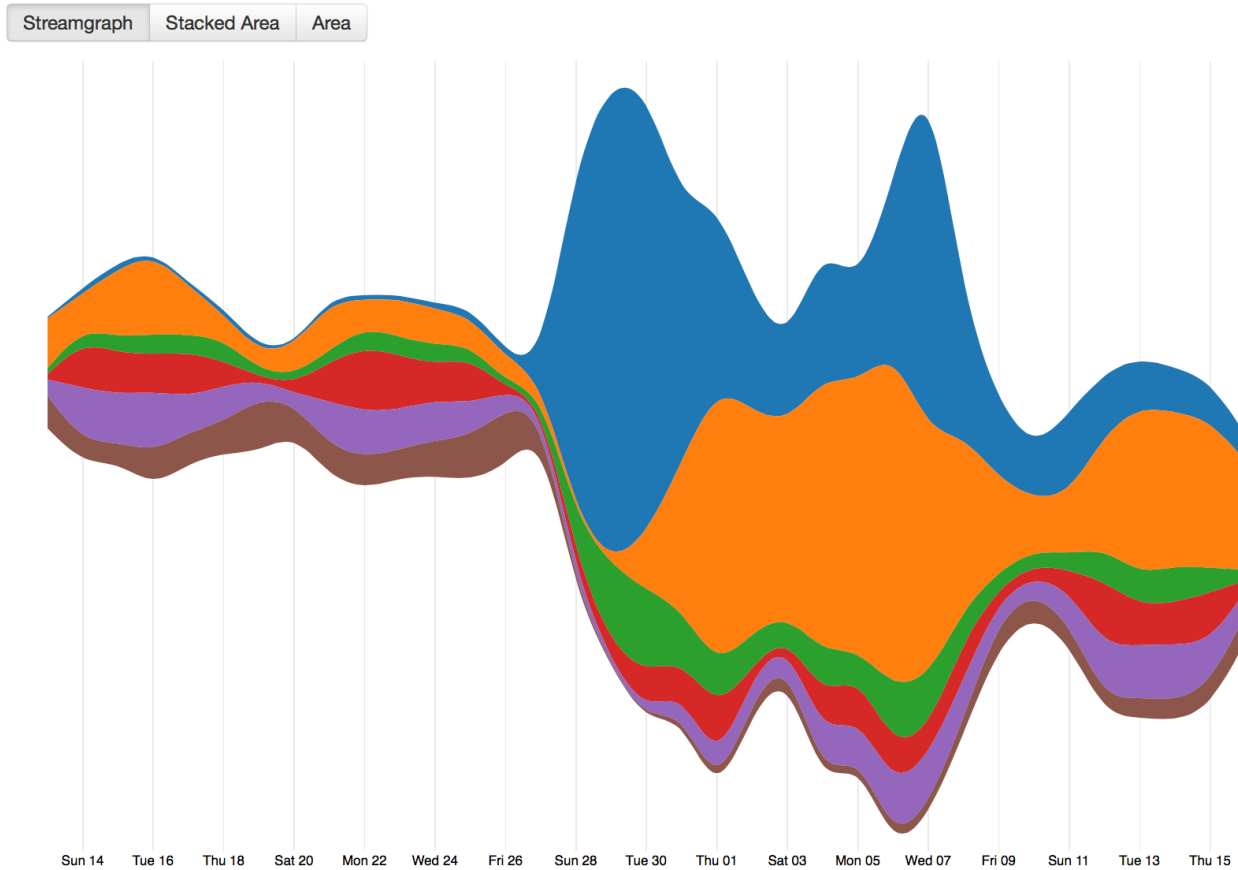
girls

1000	500	100	25	1
------	-----	-----	----	---

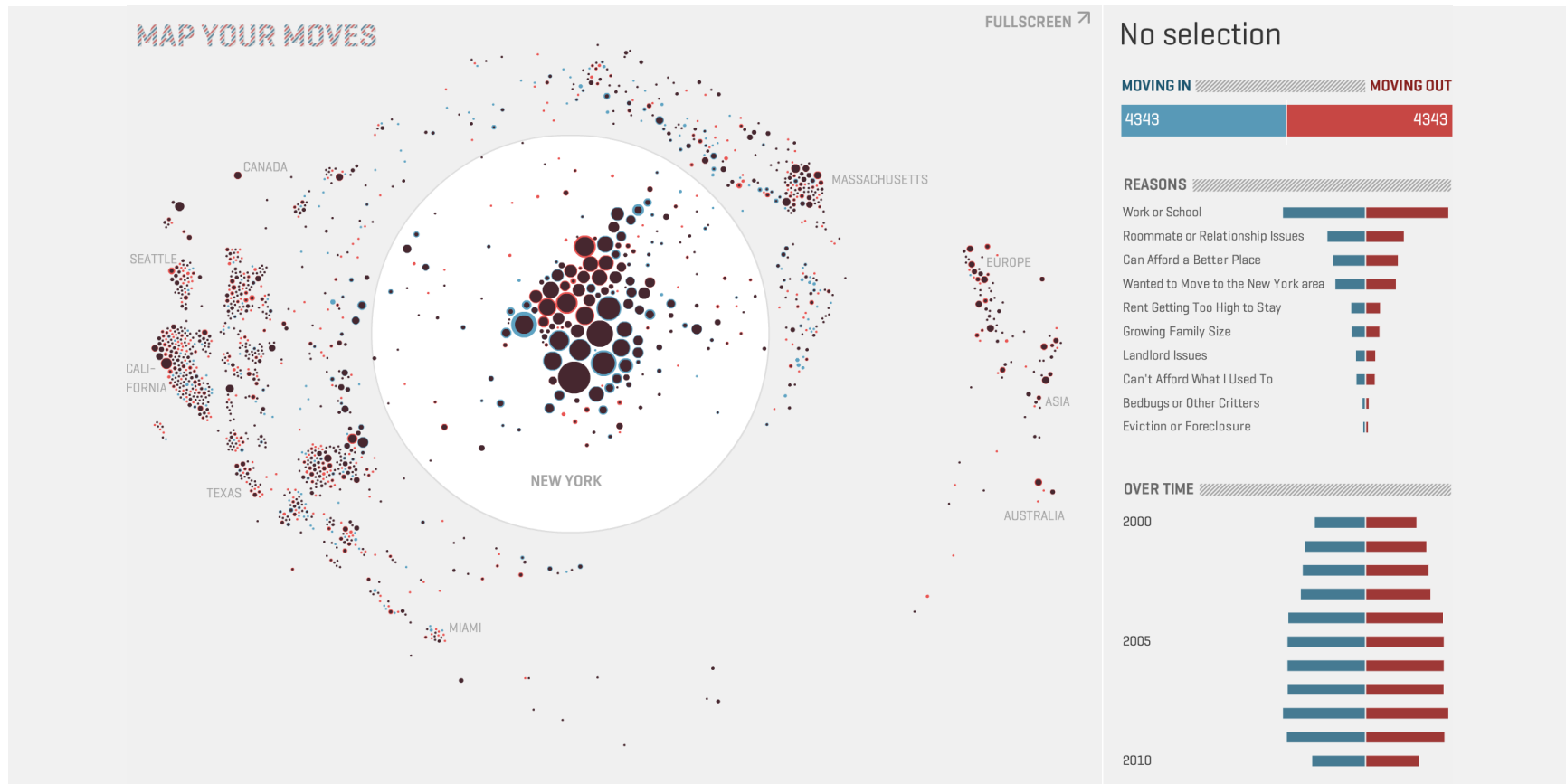
Names starting with 'A' per million babies



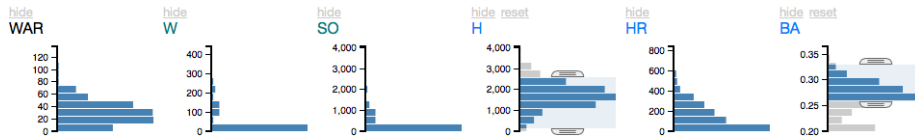
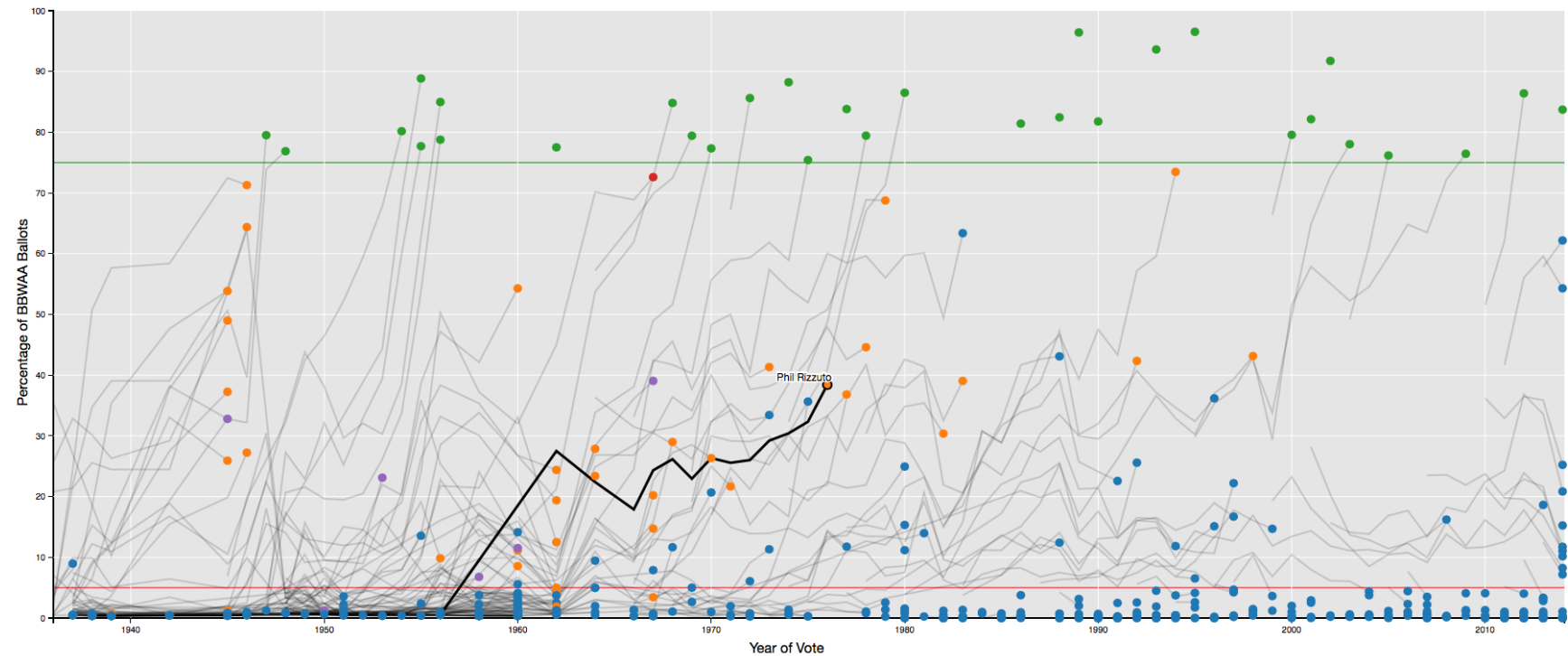
<http://www.babynamewizard.com/>



http://projects.flowingdata.com/tut/chart_transitions_demo/



<http://moritz.stefaner.eu/projects/map%20your%20moves/>



<http://cscheid.net/static/mlb-hall-of-fame-voting/>

D3 Resources

- D3 API
 - <https://github.com/mbostock/d3/wiki/SVG-Controls>
 - https://github.com/mbostock/d3/wiki/Selections#d3_event
 - <https://github.com/mbostock/d3/wiki/Behaviors>
- DOM Events
 - <https://developer.mozilla.org/en-US/docs/Web/API/Event>
- Other
 - <http://stackoverflow.com/questions/11206015/clicking-a-node-in-d3-from-a-button-outside-the-svg/11211391>
 - <http://bl.ocks.org/mbostock/5872848>



Resources

- Stephen Few, "Now You See It: Simple Visualization Techniques for Quantitative Analysis," Analytics Press, California, 2009.
- Riccardo Mazza, "Introduction to Information Visualization," Springer-Verlag, London, 2009.
- Andy Cockburn, Amy Karlson, and Benjamin B. Bederson, "A Review of Overview+Detail, Zooming, and Focus+Context Interfaces," ACM Computing Surveys, Volume 41, Number 1, Article 2, December 2008.
- Jeffery Heer and Ben Shneiderman, "Interactive Dynamics for Visual Analytics," ACM Queue, Volume 10, Number 2, February 2012.



QUESTIONS

<http://sjengle.cs.usfca.edu/>

