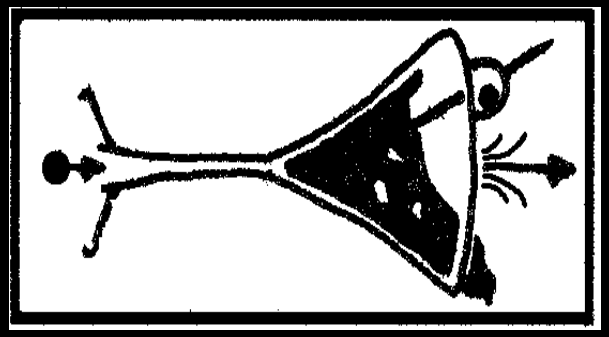
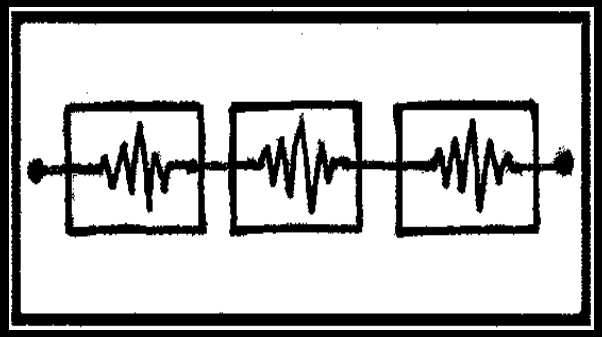
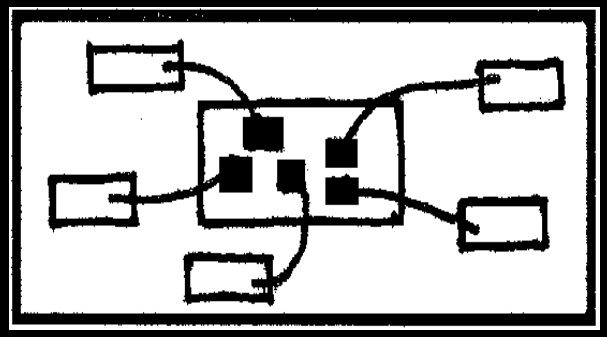
CSE 512 - Data Visualization

Narrative Visualization







Matthew Conlen University of Washington

(with material from Jeff Heer, Edward Segel, and Jessica Hullman)

STORYTELLING

as ancient as mankind

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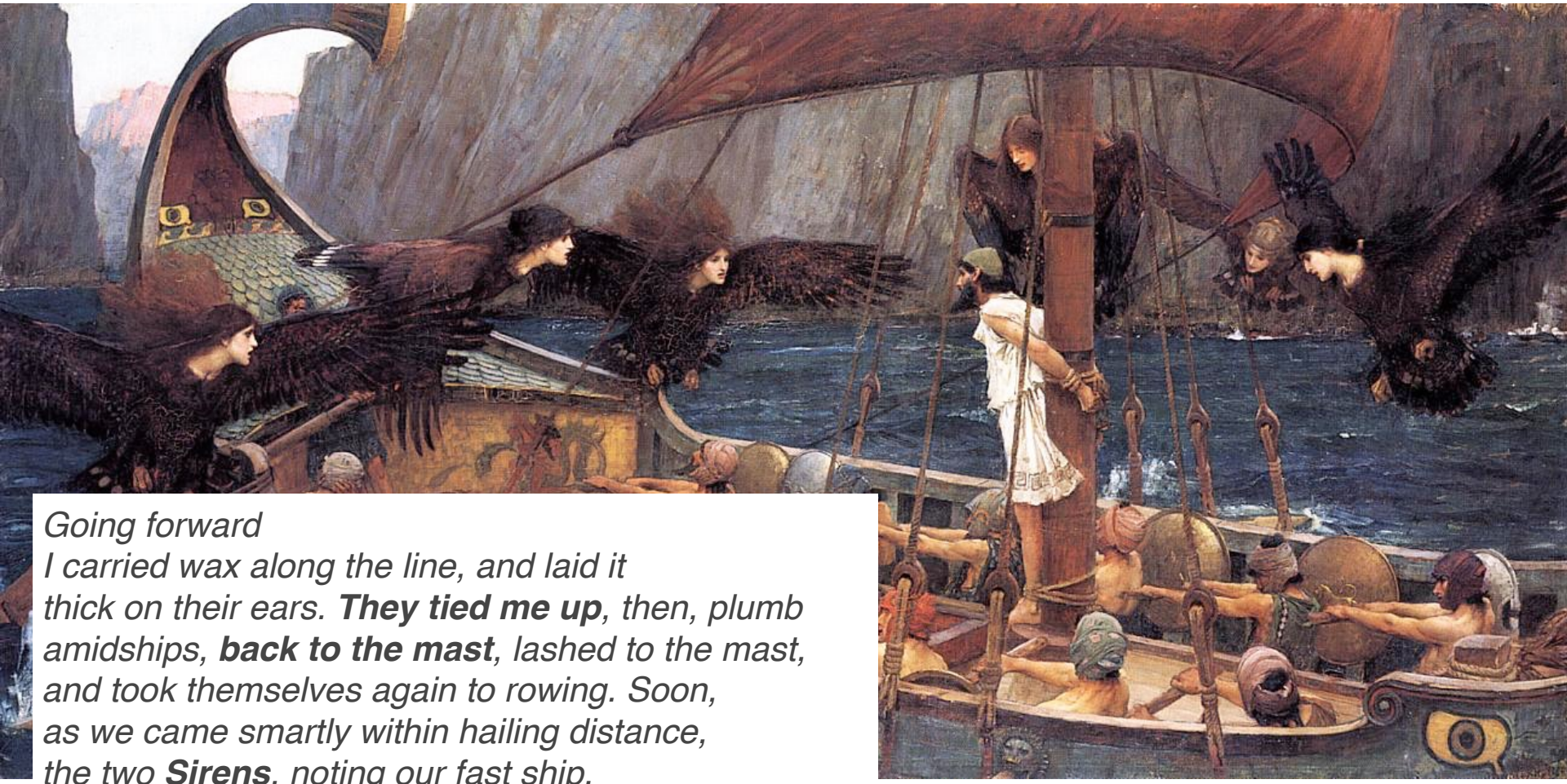
as ancient as mankind



Going forward
I carried wax along the line, and laid it
thick on their ears. ***They tied me up****, then, plumb*
amidships, ***back to the mast****, lashed to the mast,*
and took themselves again to rowing. Soon,
as we came smartly within hailing distance,
the two ***Sirens****, noting our fast ship,*
off their point, ***made ready, and they sang****…*

STORYTELLING

across various media

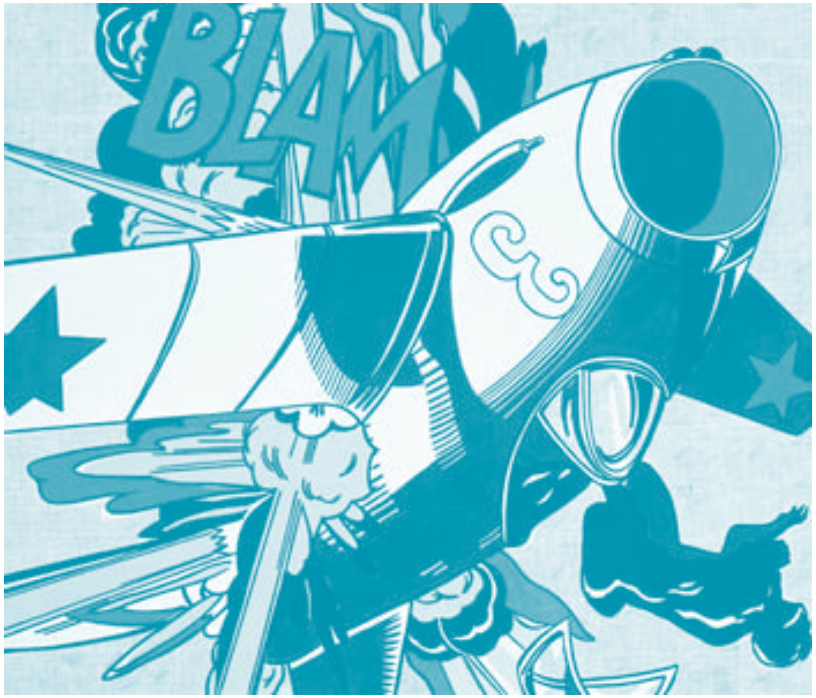
PEOPLE TELL STORIES

WORDS TELL STORIES

IMAGES TELL STORIES

COMICS TELL STORIES

MOVIES TELL STORIES



Narrative Story-Telling

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narrative (n): An account of a series of events, facts, etc., given in order and with the establishing of connections between them.

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Effective story-telling “require[s] skills like those familiar to movie directors, beyond a technical expert’s knowledge of computer engineering and science.” - Gershon & Page ‘01

August 26, 2010

Generals Wary of Move to Cut Their Ranks

By GINGER THOMPSON and THOM SHANKER

WASHINGTON — Maj. Gen. Paul D. Eaton, a retired Army officer, is familiar with the perks and pitfalls of power, having commanded tens of thousands of troops at Fort Benning, Ga., managed budgets exceeding $2 billion in Iraq, and overseen layers upon layers of staff members who helped manage both his professional duties and his personal life.

He has experienced the full range of lifestyles that come with military leadership, living at one point in an elegant antebellum mansion, and at another, with eight other officers crowded in a marble bathhouse behind one of Saddam Hussein's old palaces.

When he traveled, he was occasionally able to justify the use of military aircraft, but most times, he said, he flew coach. And today he lives on a pension worth 75 percent of his military salary, with health benefits that cover everything except dental and eye care for himself and his wife.

"We are well compensated, and we live very comfortable lives," General Eaton said, referring to the military's most senior leaders. "But when you look at all the things going on around a general, the nation is getting a very, very high return on its money."

Not everyone at the Pentagon agrees. Two weeks ago, Defense Secretary Robert M. Gates announced a sweeping effort to improve efficiency that, among other things, takes aim at the military's sacrosanct corps of generals and admirals, ordering his staff to cut at least 50 positions, and making clear that he would be happier if they cut more.

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Anecdotal Lead

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Nut Graph

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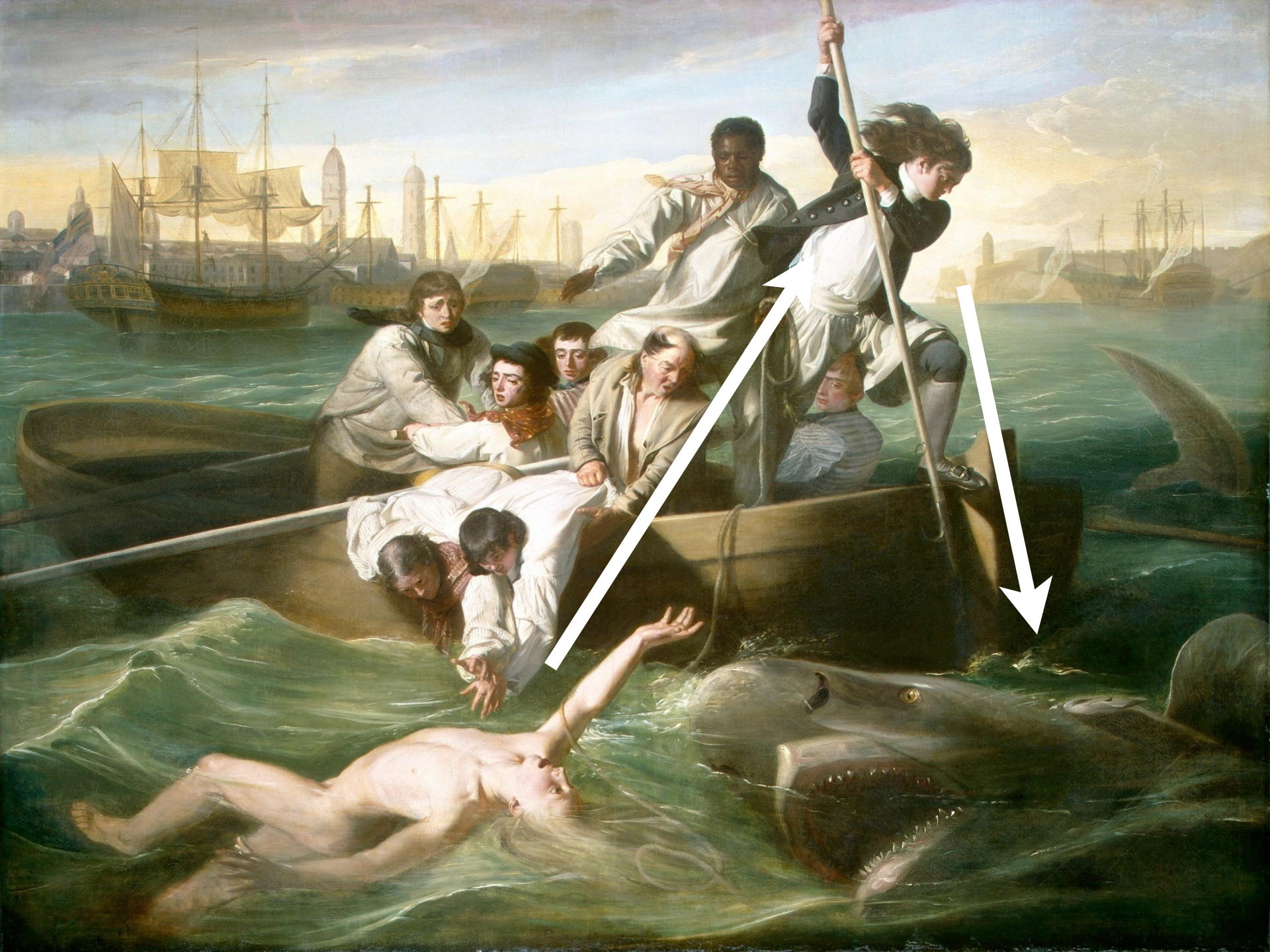
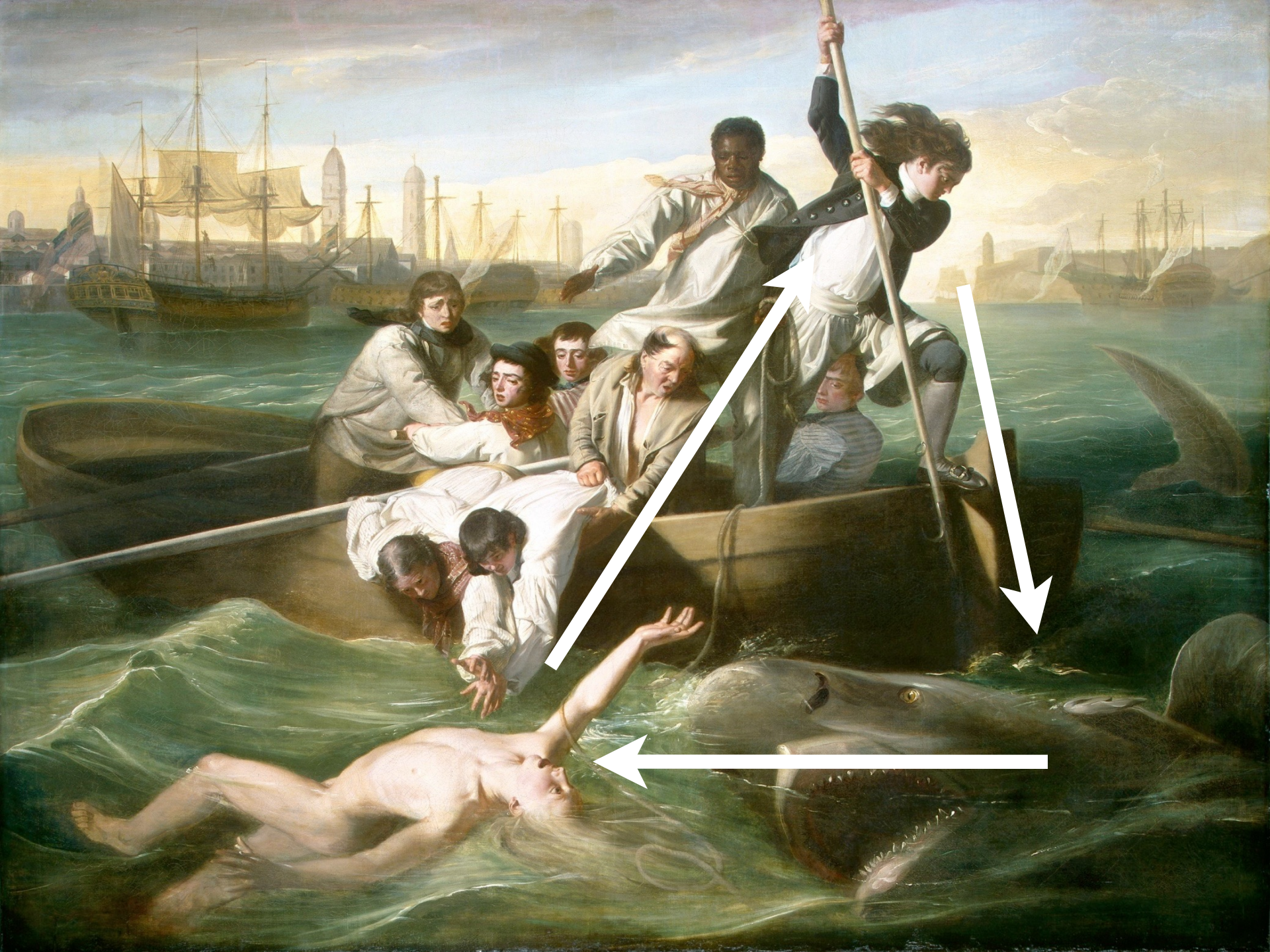





BLAM!









Topics

Narrative visualization design

Navigation in interactive documents

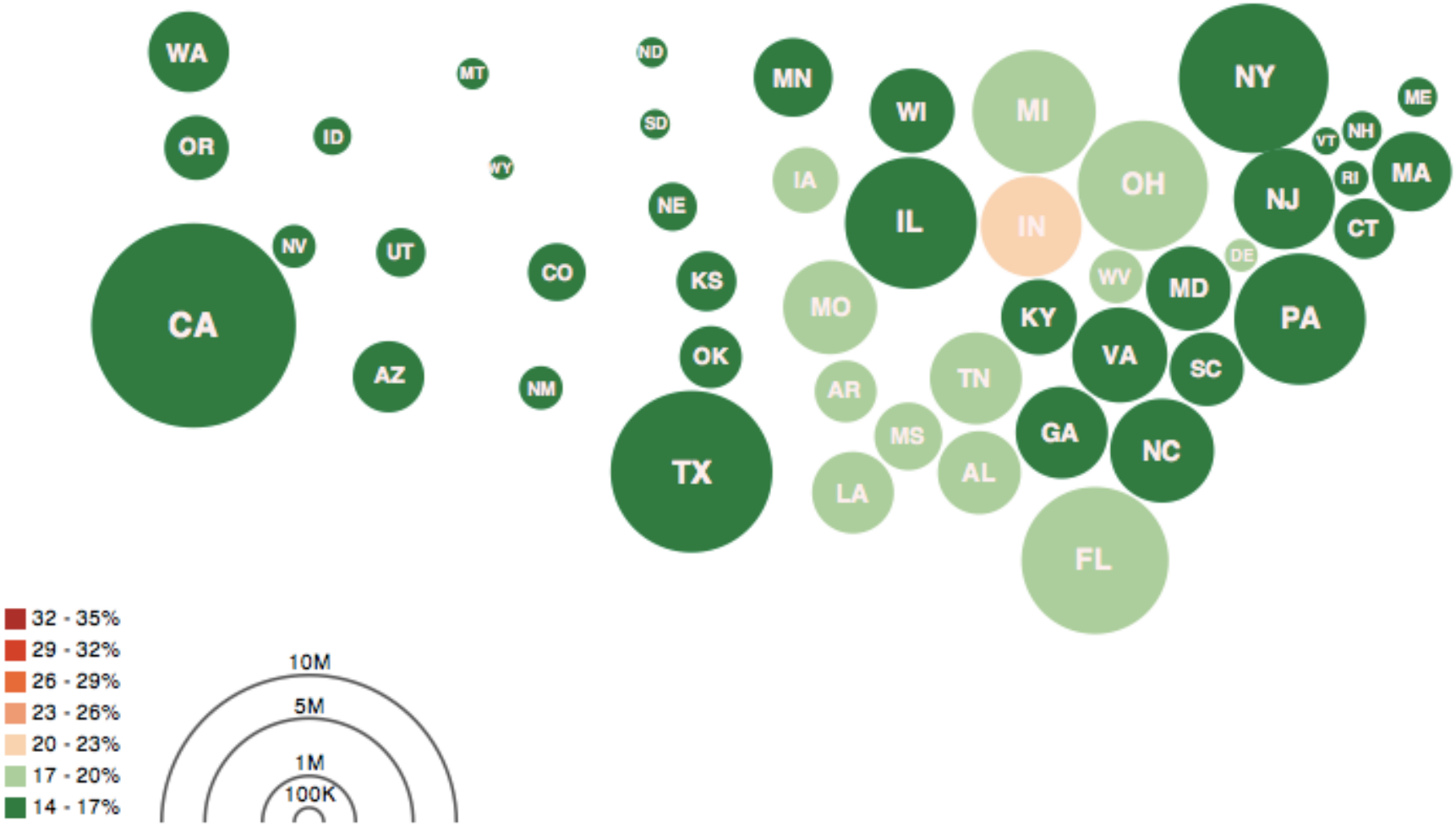
Narrative Vis + Science

Tools for creating interactive documents

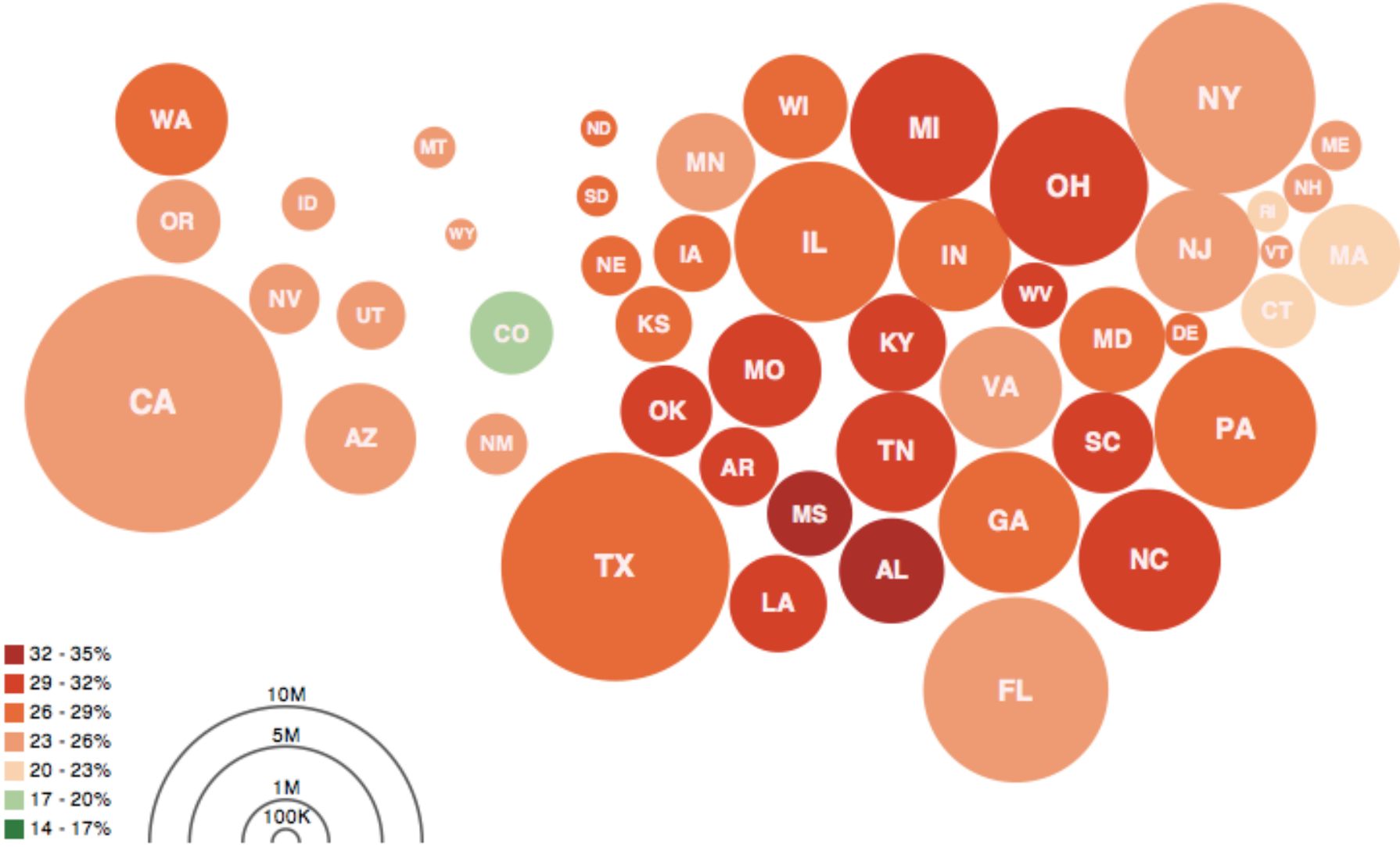
Evaluating interactive articles

Chart sequence models

Storytelling
… with data?



Obesity Map Vadim Ogievetsky



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Also in this section

For daily analysis and debate on business, visit
Economist.com/business-finance

Privacy and the internet

Lives of others

Facebook and Google face a backlash from users and regulators alike over the way they have handled sensitive data

JENNIFER STODDART, Canada's privacy commissioner, [illegible] with Facebook. In August 2009 the social networking site struck a deal, agreeing to change its policies within a year to comply with the country's privacy law. Now, says Ms Stoddart, the company appears to be reneging on an important part of the deal, which involved giving users a clear and easy-to-implement choice over whether to share private data with third parties. "It doesn't seem to me that Facebook is going in the right direction on this issue," she says, hinting that, without a change of course, the firm could soon become the subject of another formal investigation by her organisation.

Facebook is not the only internet giant to provoke the ire of data watchdogs. Google endured withering criticism this week following news that it had recorded some personal communications sent over unsecured Wi-Fi data networks in homes and offices in some 30 countries. On May 15th Peter Schaar, Germany's federal commissioner for data protection, called for an independent investigation into Google's behaviour, claiming that it had "simply disregarded normal rules in the development and usage of software."

The news highlights rising tension between guardians of privacy and internet firms. And they reflect concern among web users about how private data are made public. Several prominent internet types such as Cory Doctorow, a science-fiction author, and Leo Laporte, a podcaster, have abandoned Facebook. Sites such as QuitFacebookDay.com are urging others to do so, nominating May 31st for a mass Facebook "suicide".

This is unlikely to stop the meteoric rise of Facebook, which is poised to claim half a billion members and which draws even more visitors as a whole to its site (see chart). But nerves have been rattled at the company's headquarters in Silicon Valley, where bosses are mulling over how to respond. Several senior folk are now hinting that Facebook will soon roll out simpler privacy controls to make it easier to keep more data hidden. MySpace, a rival, is already making its controls simpler in an effort to woo disaffected Facebookers to its service.

A revolt over Facebook's handling of privacy has been brewing for some time. In December the social network changed the default settings on its privacy controls so that individuals' personal information would be shared with "everyone" rather than selected friends. Facebook argued this reflected a shift in society towards greater openness and noted that users could still adjust privacy settings back again. But incensed privacy activists lobbied for it to be reversed.

The switch should not have come as a surprise. Early on, many social networks impose fairly tough privacy policies in order to attract and reassure users. But as more join, controls are gradually loosened to encourage more sharing. As people share more, Facebook can increase the traffic against which it sells advertising. And the more it learns about users' likes and dislikes, the better it can target ads that generate hundreds of millions of dollars.

Protests grew louder still following a developers' conference last month at which Mark Zuckerberg, Facebook's boss, announced yet another series of policy changes. One that caused irritation was an "instant personalisation" feature that lets certain third-party websites access Facebook data when people visit. Critics say that Facebook has made it tricky to disable this feature, which may explain why its [illegible] so much.

European officials are grumbling about Facebook too. This month a group of data-protection experts who advise the European Commission wrote to the social network, calling its decision to loosen the default settings "unacceptable". And as the

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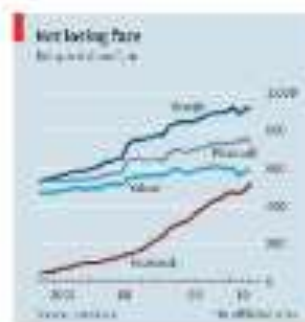
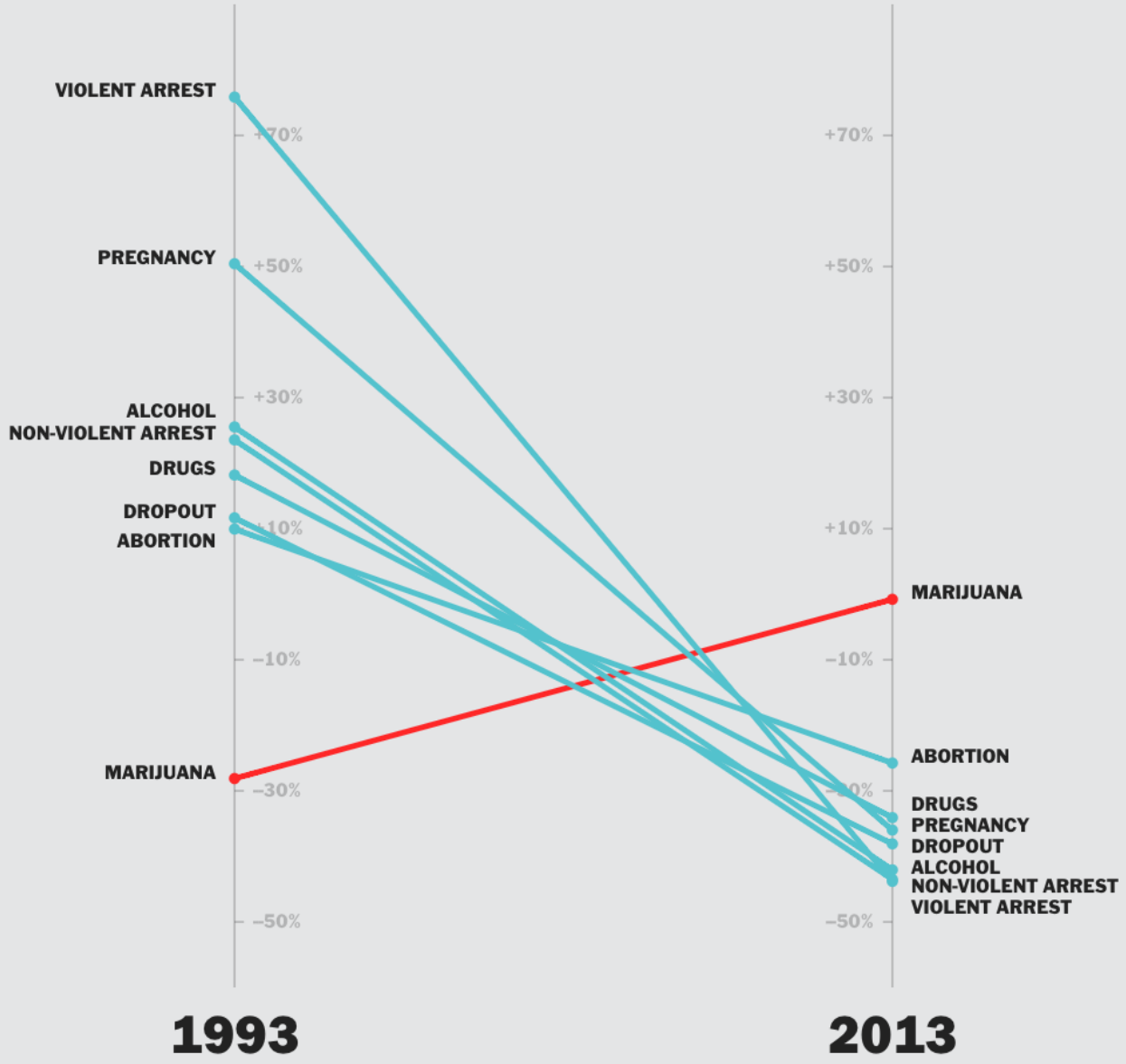
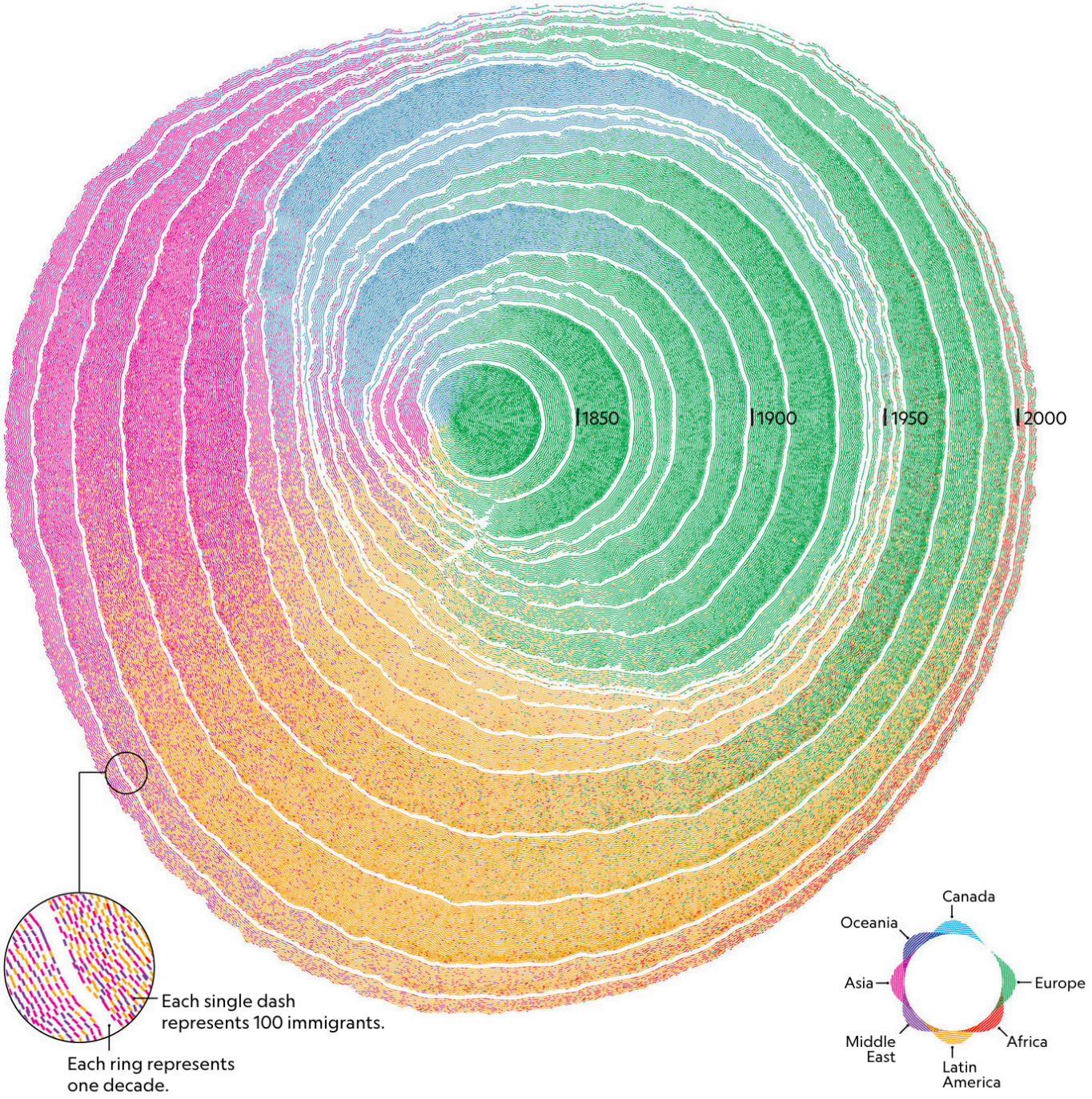


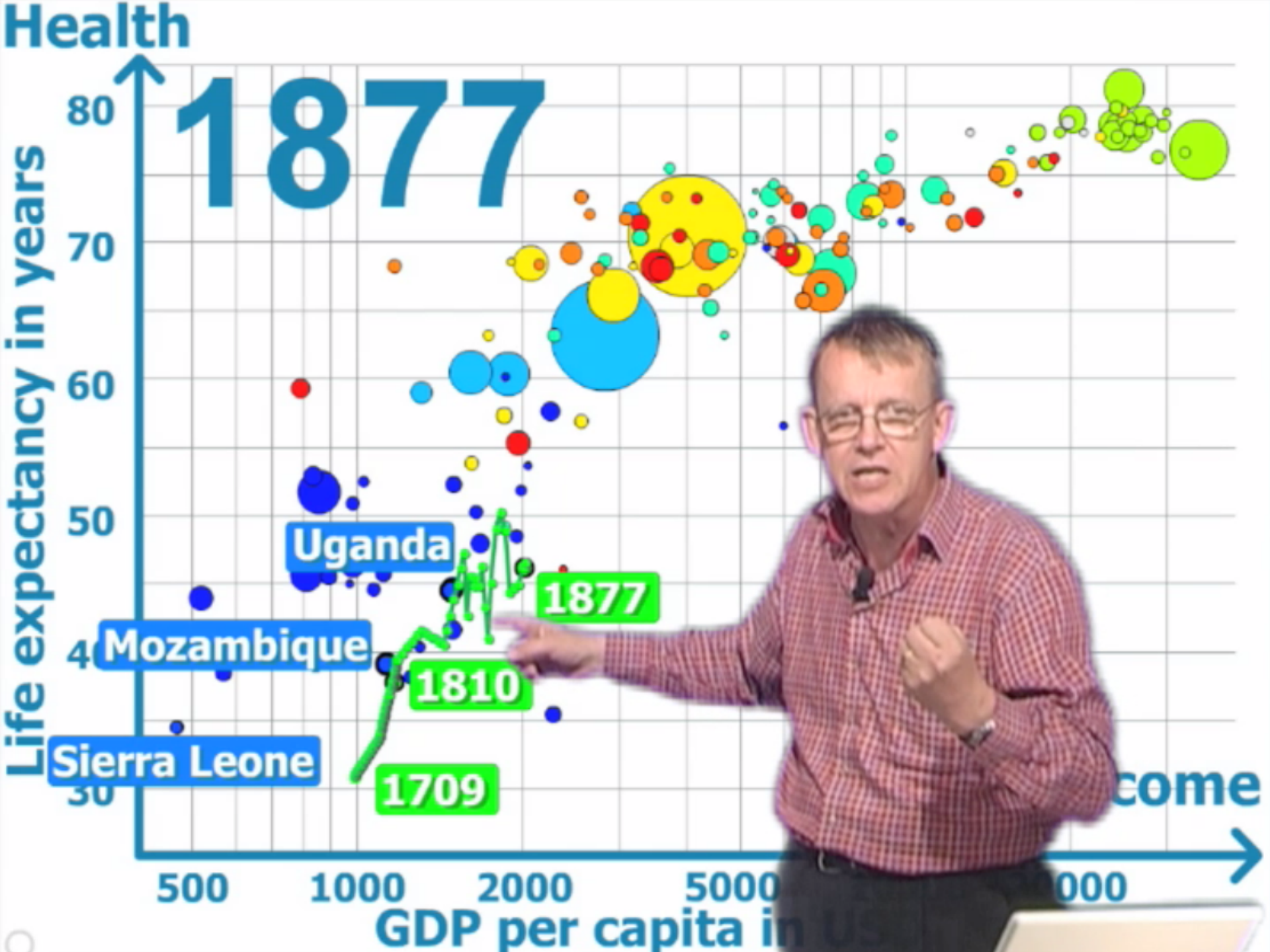
Not losing face

SHENANIGANS

Change in teen shenanigans from 1993 to 2013.
Showing % difference from 2003 levels.




1850
1900
1950
2000
Each single dash
represents 100 immigrants.
Each ring represents
one decade.
Canada
Oceania
Asia
Europe
Middle
East
Africa
Latin
America

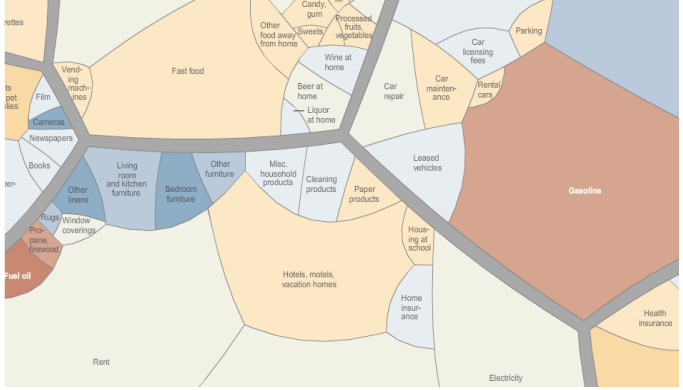

Health
1877
80
70
60
50
40
30
Life expectancy in years
Uganda
1877
Mozambique
1810
Sierra Leone
1709
500
1000
2000
5000
come
GDP per capita in

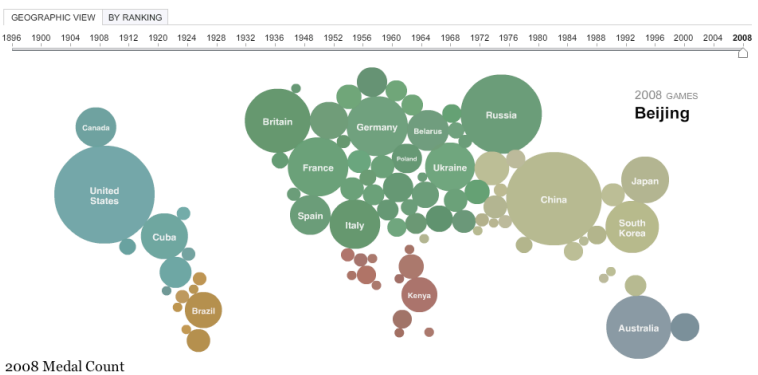
Narrative Devices for Storytelling with Data

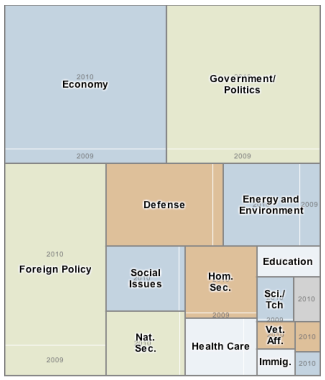
What devices communicate effectively?

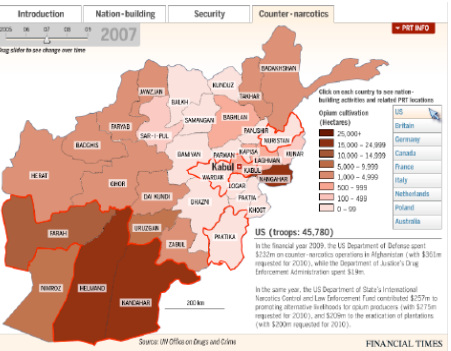
... for which contexts and audiences?

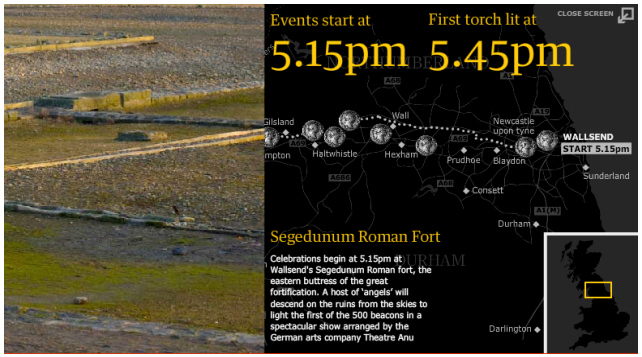
Narrative Visualization Design Space

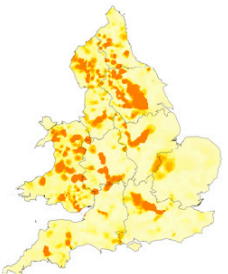


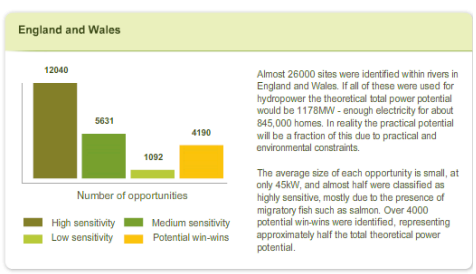












58

CASE STUDIES

70% Journalism
20% Business
10% Research

755

Steroids or Not, the Pursuit Is On

Barry Bonds is taking aim at the career home run record. He needs only six more to tie Babe Ruth and 47 to equal Hank Aaron.

Lines are cumulative home runs.

Hank Aaron
755 homers
23 seasons

Babe Ruth
714 homers
22 seasons

Barry Bonds
708 homers
20 seasons

Bonds takes lead
Home runs after 16 seasons

Bonds	567
Aaron	554
Ruth	516

755
714
23 seasons
22 seasons
20 seasons
Bonds was injured last season. He played 14 games and hit 5 homers.

600
400
200
0
14th season
5 seasons
10
15

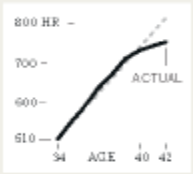
According to allegations in a book about Bonds, he began taking steroids before the 1999 season, his 14th in the league. Two seasons later, he hit 73 home runs, surpassing Aaron's career pace.

Homer Pace After Age 34

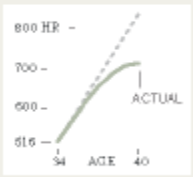
If the accusations are correct, Bonds was 34 in his first season on steroids. Here are projected home run paces for each player after age 34.

PROJECTED PACE BASED ON AVERAGE OF PREVIOUS FIVE SEASONS

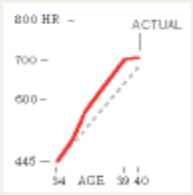
Aaron
Actual homers slightly outpace projected homers for five seasons.



Ruth
Averaged 46.4 homers a season from age 30 to 34. Averaged 42.5 for next four seasons.



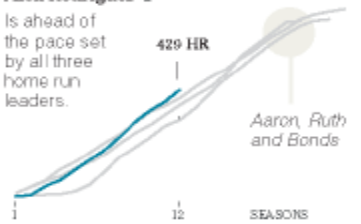
Bonds
From age 35 to 39, he averaged 14 more homers a season than projected.



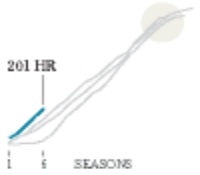
Note: Ages as of July 1 of each season.

Others Taking Aim

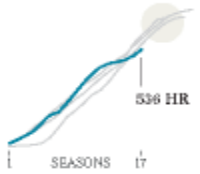
Alex Rodriguez ▲
Is ahead of the pace set by all three home run leaders.



Albert Pujols
Averaging 40 homers a season, he has started stronger than the three leaders did.



Ken Griffey Jr.
Many thought he would be the first to catch Ruth and Aaron until injuries limited his output.



Differing Paths to the Top of the Charts

The top seven players on the career home run list, along with a look at Griffey (12th), Rodriguez (37th) and Pujols (tied 257th).

Amanda Cox and Joe Ward/The New York Times

755

Grab attention with image and position

rsuit Is On

. He needs
on.

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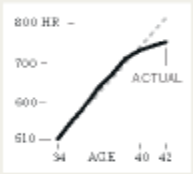

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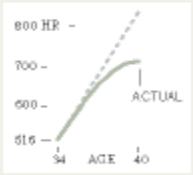

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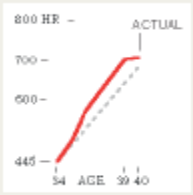

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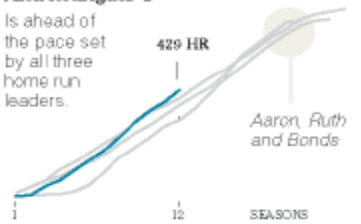

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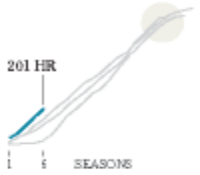

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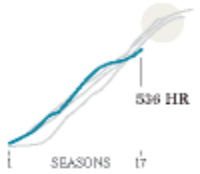

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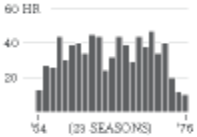
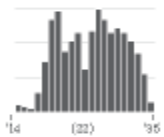


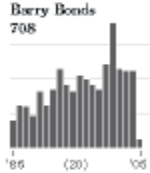
15 times hit 30 or more (M.L. most).

Babe Ruth
714



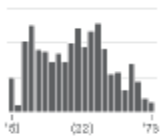
Hit only 20 over first five seasons.

Barry Bonds
708



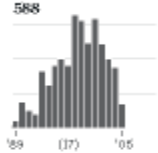
Averaged 52 from 2000 to 2004.

Willie Mays
660



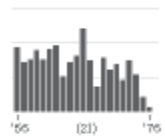
No one hit more from 1950-69.

Sammy Sosa
588



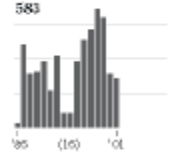
Three 60-homer seasons is record.

Frank Robinson
586



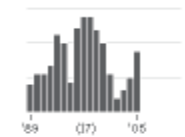
Triple Crown in '66 (49, 122, .316).

Mark McGwire
583



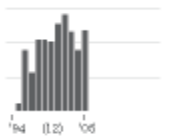
First to hit 70 in a season.

Ken Griffey Jr.
536



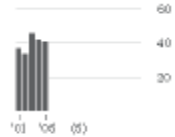
Only McGwire had more in the 90's.

Alex Rodriguez
429



Youngest to reach 400 homers.

Albert Pujols
201



Second most ever in first five seasons.

Amanda Cox and Joe Ward/The New York Times

755

Grab attention with image and position

...rsuit Is On

...He needs ...on.

...cumulative home runs.

Hank Aaron
755 homers
23 seasons

Babe Ruth
714 homers
22 seasons

Barry Bonds
708 homers
20 seasons

Bonds takes lead
Home runs after 16 seasons

Bonds	567
Aaron	554
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755
714
23 seasons
22 seasons
20 seasons

Bonds was injured last season. He played 14 games and hit 5 homers.

600
400
200
0
5 seasons
10
15

Matching on content

14th season

According to allegations in a book about Bonds, he began taking steroids before the 1999 season, his 14th in the league. Two seasons later, he hit 73 home runs, surpassing Aaron's career pace.

Homer Pace After Age 34

If the accusations are correct, Bonds was 34 in his first season on steroids. Here are projected home run paces for each player after age 34.

PROJECTED PACE BASED ON AVERAGE OF PREVIOUS FIVE SEASONS

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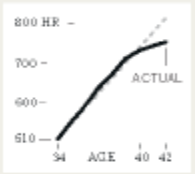
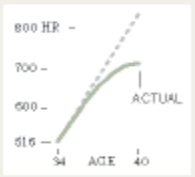
Actual homers slightly outpace projected homers for five seasons.



Ruth
Averaged 46.4 homers a season from age 30 to 34. Averaged 42.5 for next four seasons.



Bonds
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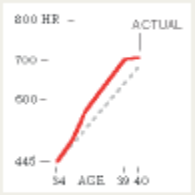
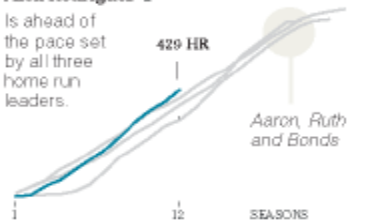


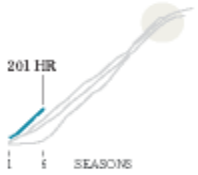
Note: Ages as of July 1 of each season.

Others Taking Aim

Alex Rodriguez ▲
Is ahead of the pace set by all three home run leaders.



Albert Pujols
Averaging 40 homers a season, he has started stronger than the three leaders did.



Ken Griffey Jr.
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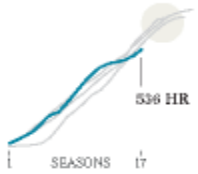

Differing Paths to the Top of the Charts

The top seven players on the career home run list, along with a look at Griffey (12th), Rodriguez (37th) and Pujols (tied 257th).

Amanda Cox and Joe Ward/The New York Times

755

Grab attention with image and position

Cumulative home runs.

Hank Aaron
755 homers
23 seasons

Babe Ruth
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20 seasons

Bonds takes lead
Home runs after 16 seasons

Bonds	567
Aaron	554
Ruth	516

400

200

0

5 seasons

10

14th

Accordi... in a boo... he begs... steroids... season,... league... later, he... runs, su... career p...

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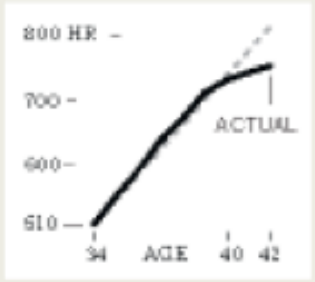

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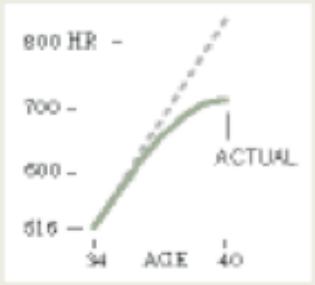

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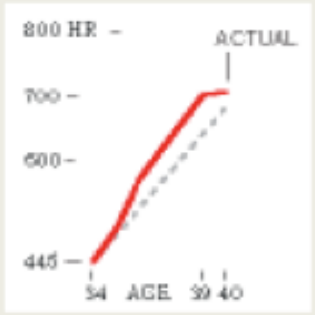

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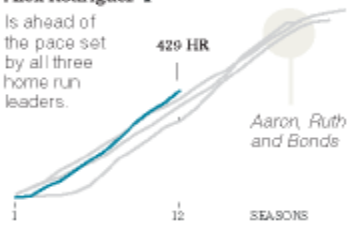

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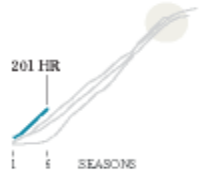

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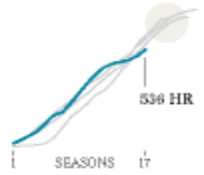
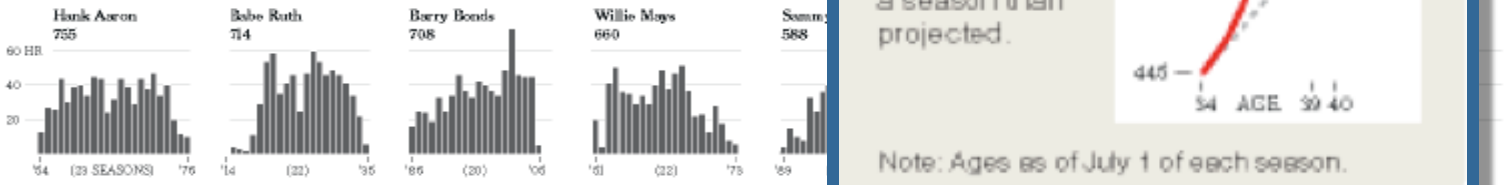


Differing Paths to the Top of the Charts

The top seven players on the career h... (257th).



Amanda Cox and Joe Ward/The New York Times

755

Grab attention with image and position

...rsuit Is On

...He needs ...on.

...cumulative home runs.

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755 homers
23 seasons

Babe Ruth
714 homers
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Barry Bonds
708 homers
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Bonds takes lead
Home runs after 16 seasons

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Aaron	554
Ruth	516

755
714
23 seasons
22 seasons
20 seasons

Bonds was injured last season. He played 14 games and hit 5 homers.

600
400
200
0
5 seasons
10
15

Matching on content

14th season

According to allegations in a book about Bonds, he began taking steroids before the 1999 season, his 14th in the league. Two seasons later, he hit 73 home runs, surpassing Aaron's career pace.

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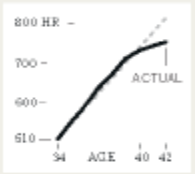

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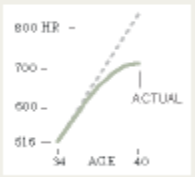

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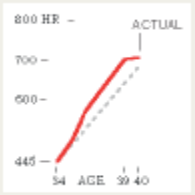

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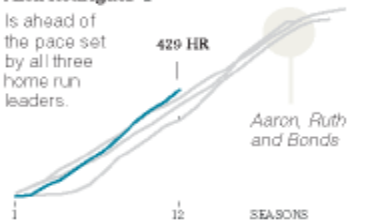

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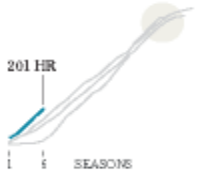

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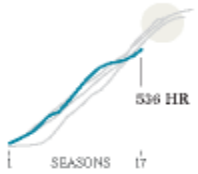

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23 seasons
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14th season
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10
15

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Matching on content

Visual prominence

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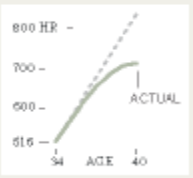

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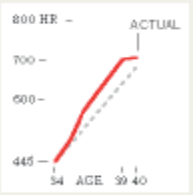

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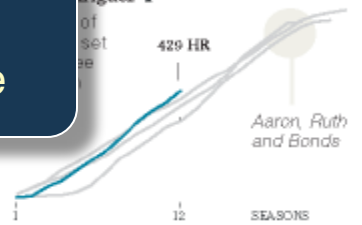
Others Taking Aim

...riguez ▲
...of ...set ...e



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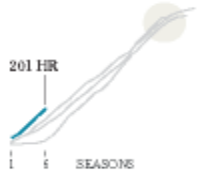

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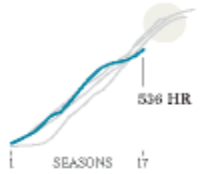

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Cumulative home runs.

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23 seasons
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Bonds was injured last season. He played 14 games and hit 5 homers.

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400
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15

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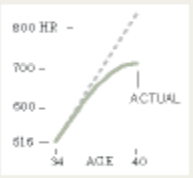

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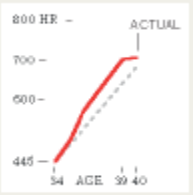
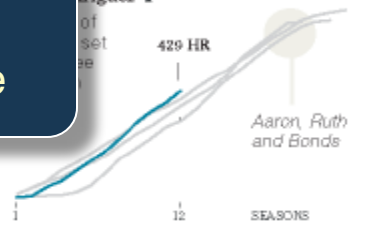


Note: Ages as of July 1 of each season.

Visual prominence

Others Taking Aim

…riguez ▲
…of
…set
…e



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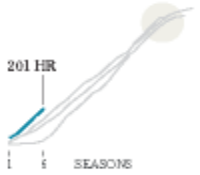

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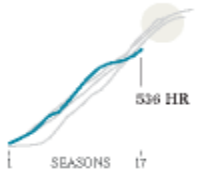

Reduced visual priority

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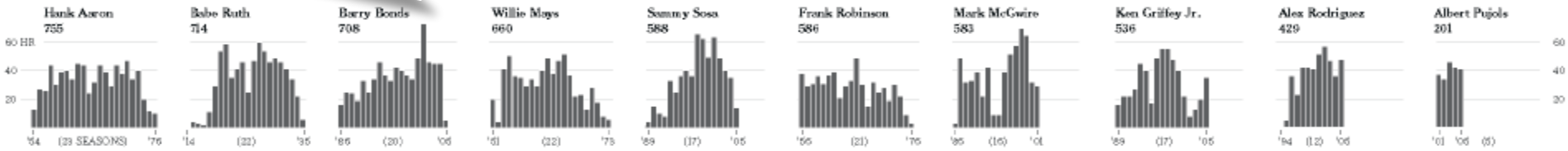

Amanda Cox and Joe Ward/The New York Times

Beginning

Middle

Steroids or Not, the Pursuit Is On

Barry Bonds is taking aim at the career home run record. He needs only one more to tie Babe Ruth and 47 to equal Hank Aaron.

Hank Aaron
755 homers
23 seasons

Babe Ruth
714 homers
22 seasons

Barry Bonds
708 homers
20 seasons

Bonds takes lead
Home runs after 16 seasons

Bonds	567
Aaron	554
Ruth	514

23 seasons
22 seasons
20 seasons

Bonds was injured last season. He played 14 games and hit 6 homers.

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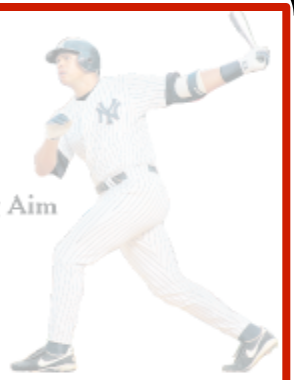
5 seasons
10
15

End



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Epilogue

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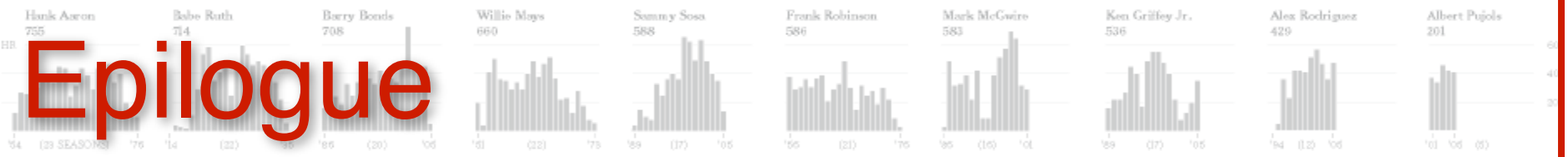

15 times hit 30 or more (M.L. most).

Hit only 20 over first five seasons.

Averaged 52 from 2000 to 2004.

No one hit more from 1950-69.

Three 60-homer seasons is record.

Triple Crown in '66 (49, 122, .316).

First to hit 70 in a season.

Only McGwire had more in the 90's.

Youngest to reach 400 homers.

Second most ever in first five seasons.

Budget 2010: reaction from around the UK

People in key constituencies around the country give their responses to Alistair Darling's budget

Paddy Allen, **Jenny Ridley** and **Carly Levene**
guardian.co.uk, Wednesday 24 March 2010 15.00 GMT

Hammersmith and Fulham

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Constituency profile
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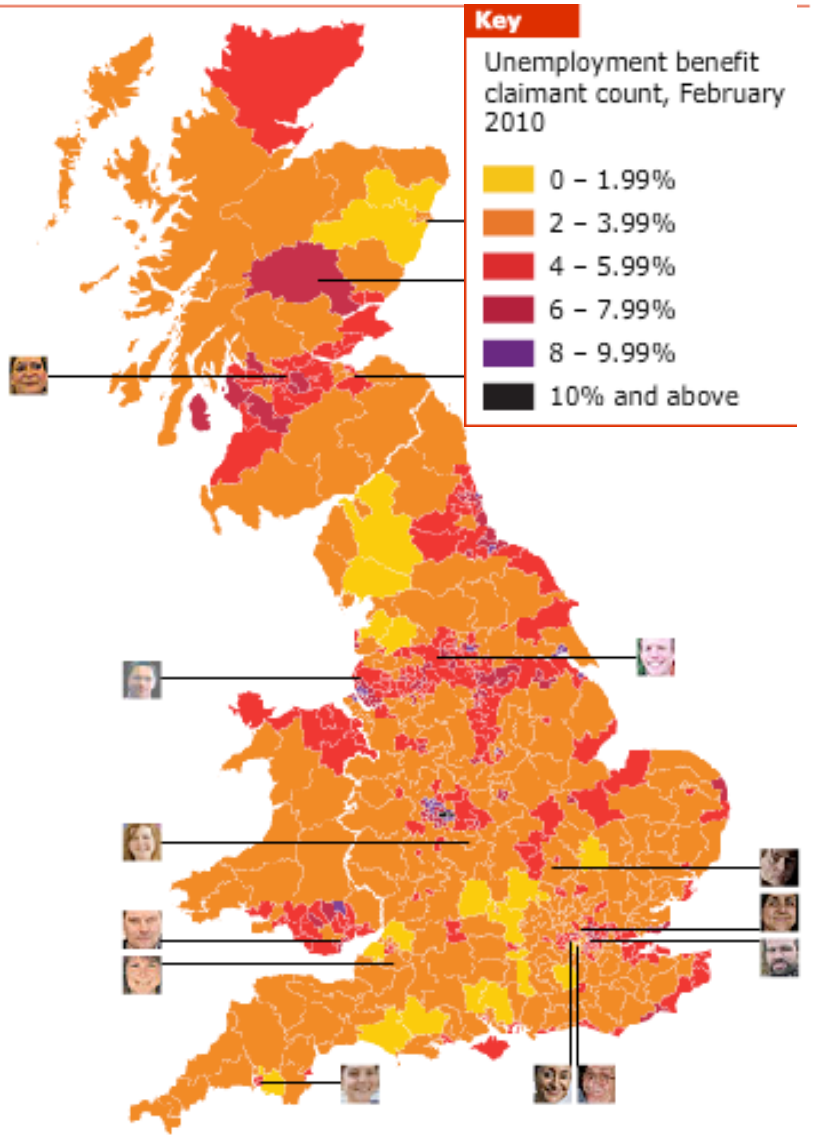
Unemployment benefit claimants, Feb 2010: 3,281 (up 13% over last year)



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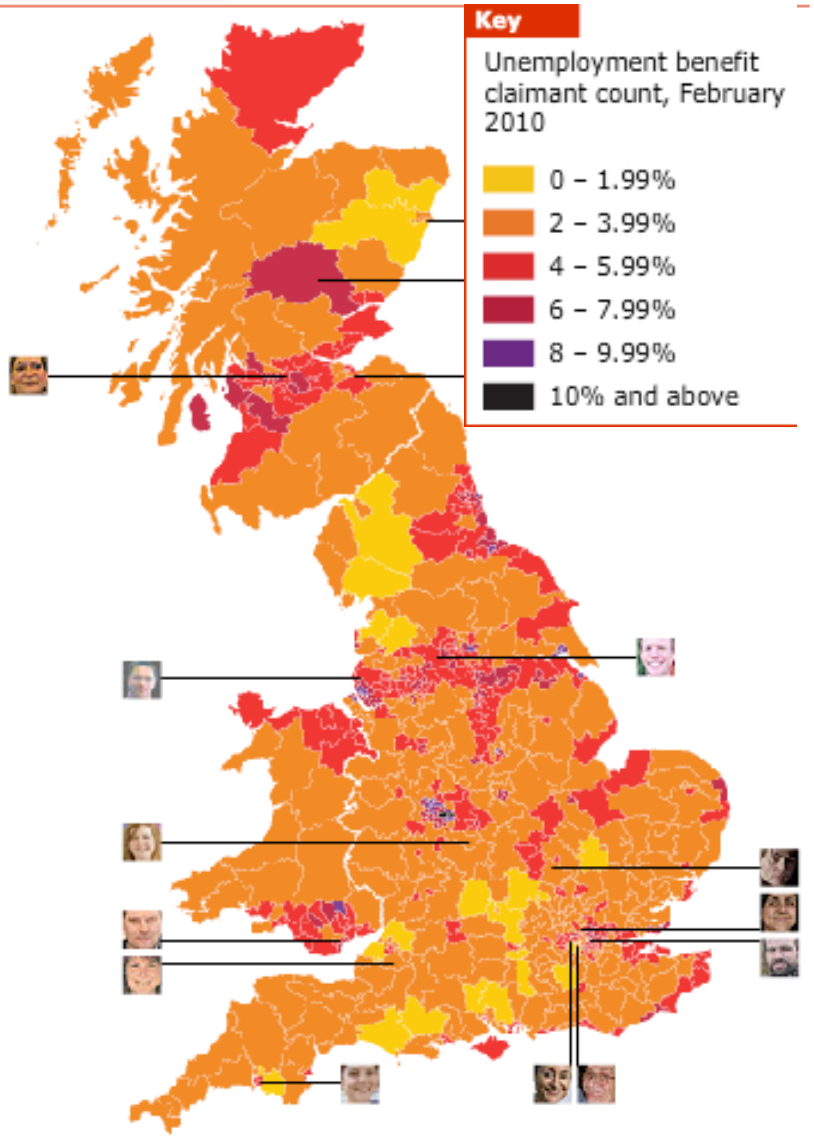

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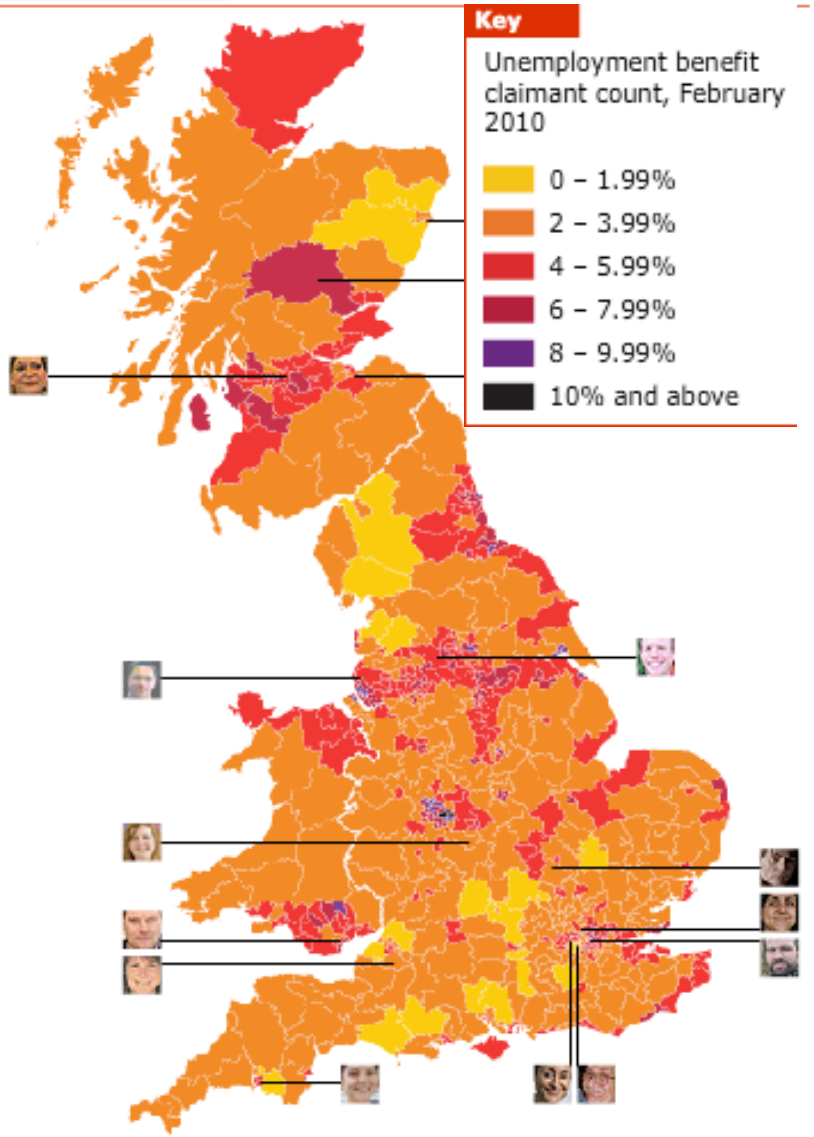

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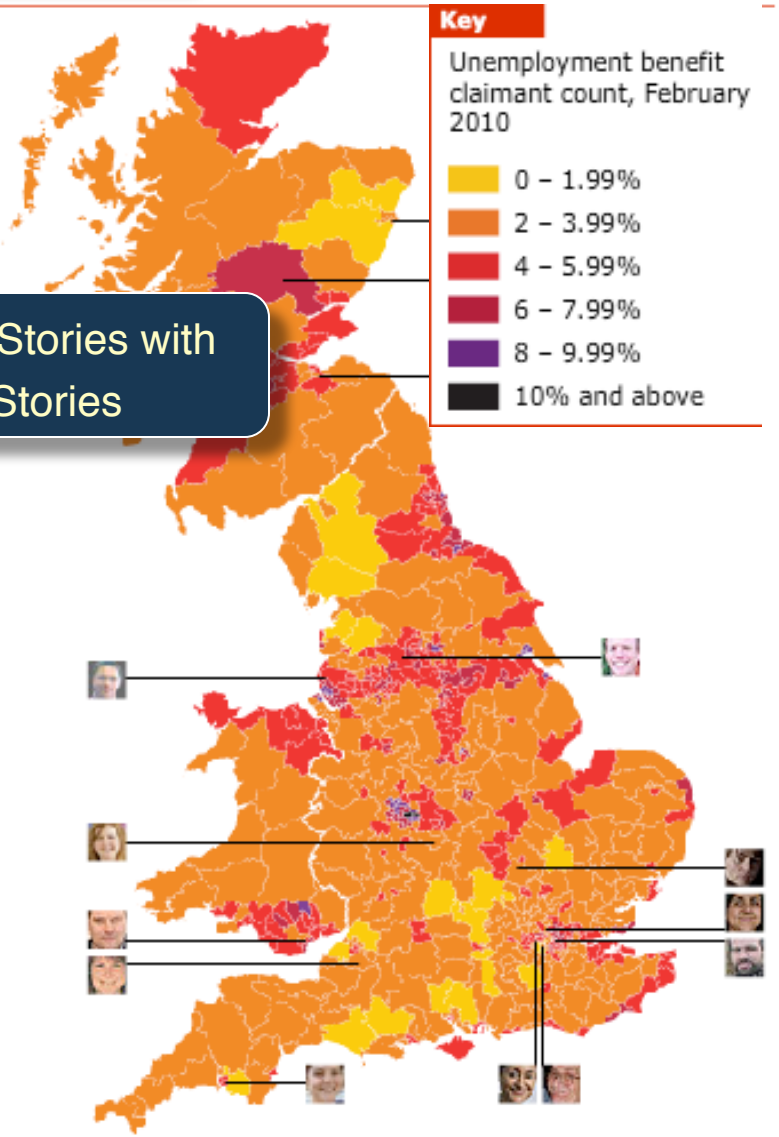
Anecdotal Stories with Data Stories



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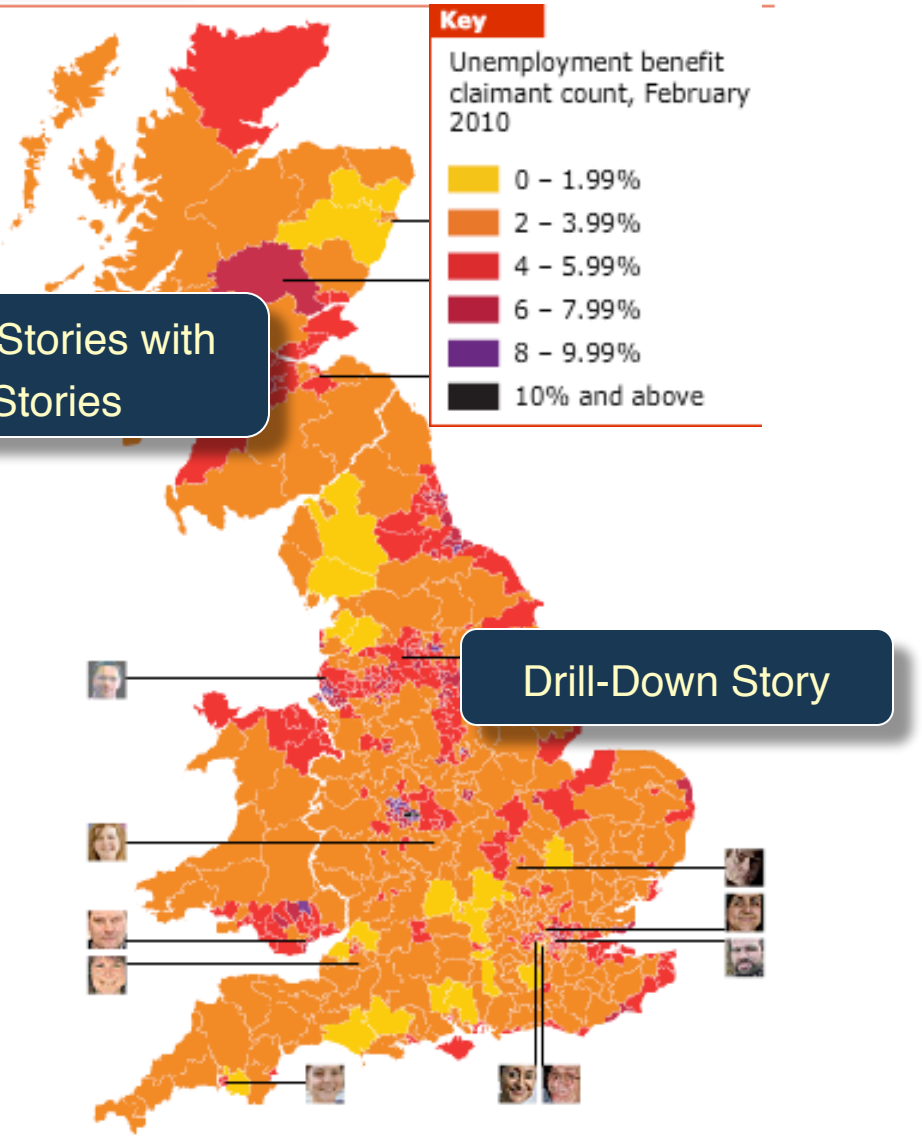

Drill-Down Story

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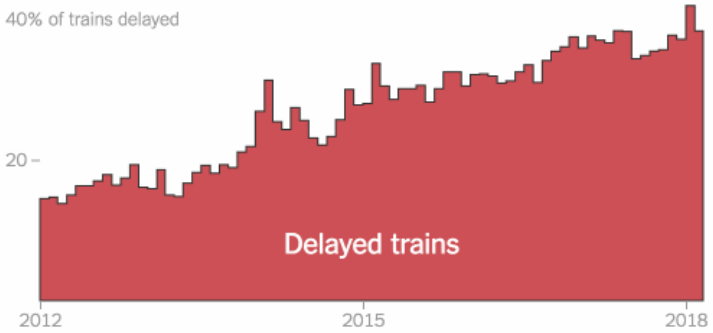
How 2 M.T.A. Decisions Pushed the Subway Into Crisis

By ADAM PEARCE MAY 9, 2018



Source: M.T.A. on-time performance data

By now, New York City commuters are familiar with the wait. We descend from the bitter cold or the stifling heat to find subway platforms teeming with other bodies trying to make it to work on time. Delays ripple through the system, so there's barely room to squeeze into the next train that

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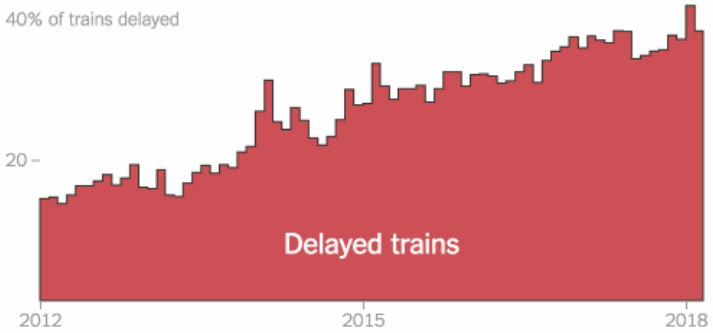

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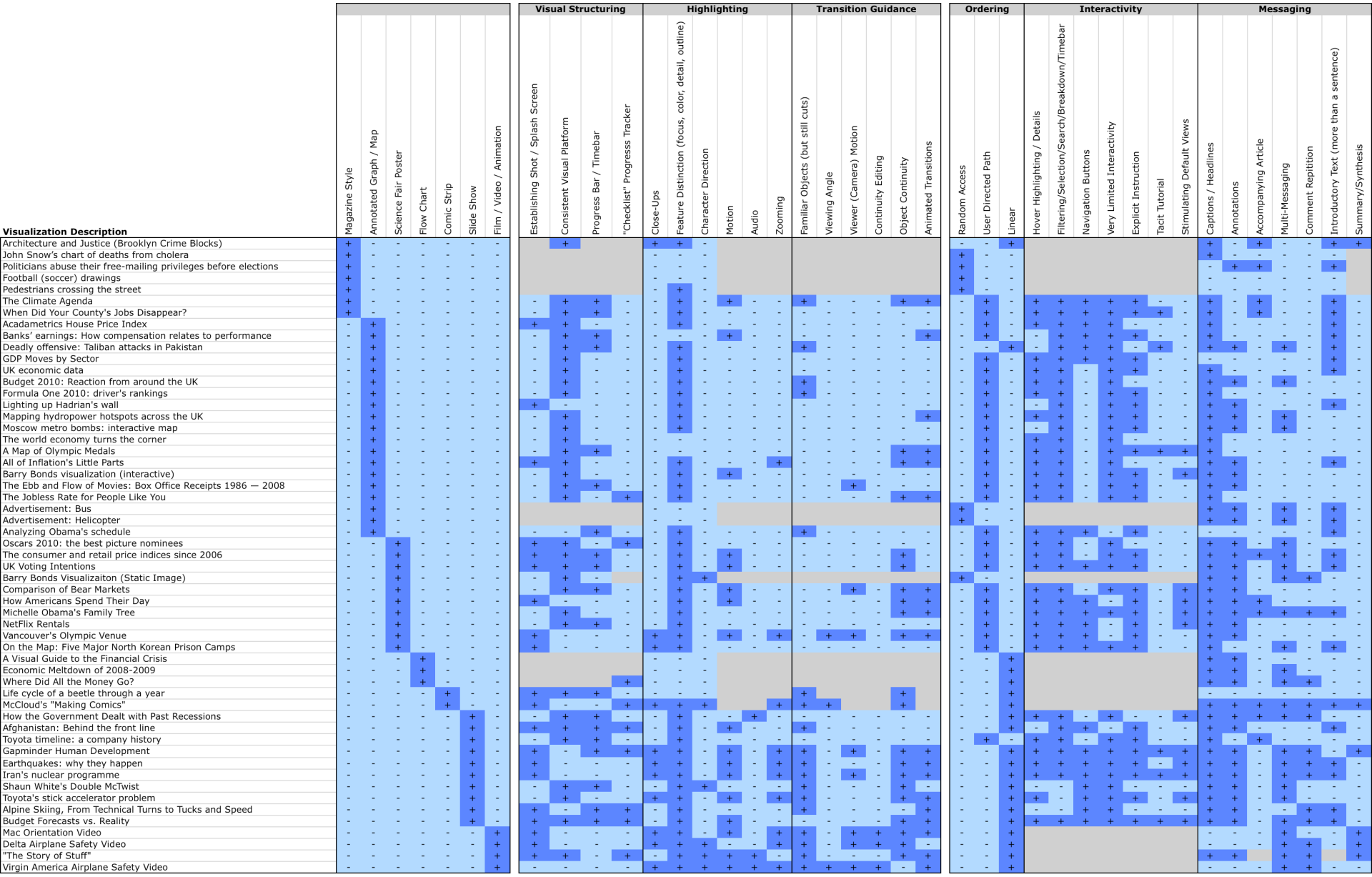
Visualization Description
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Science Fair Poster
Flow Chart
Comic Strip
Slide Show
Film / Video / Animation
Visual Structuring
Establishing Shot / Splash Screen
Consistent Visual Platform
Progress Bar / Timebar
"Checklist" Progresss Tracker
Highlighting
Close-Ups
Feature Distinction (focus, color, detail, outline)
Character Direction
Motion
Audio
Zooming
Transition Guidance
Familiar Objects (but still cuts)
Viewing Angle
Viewer (Camera) Motion
Continuity Editing
Object Continuity
Animated Transitions
Ordering
Random Access
User Directed Path
Linear
Interactivity
Hover Highlighting / Details
Filtering/Selection/Search/Breakdown/Timebar
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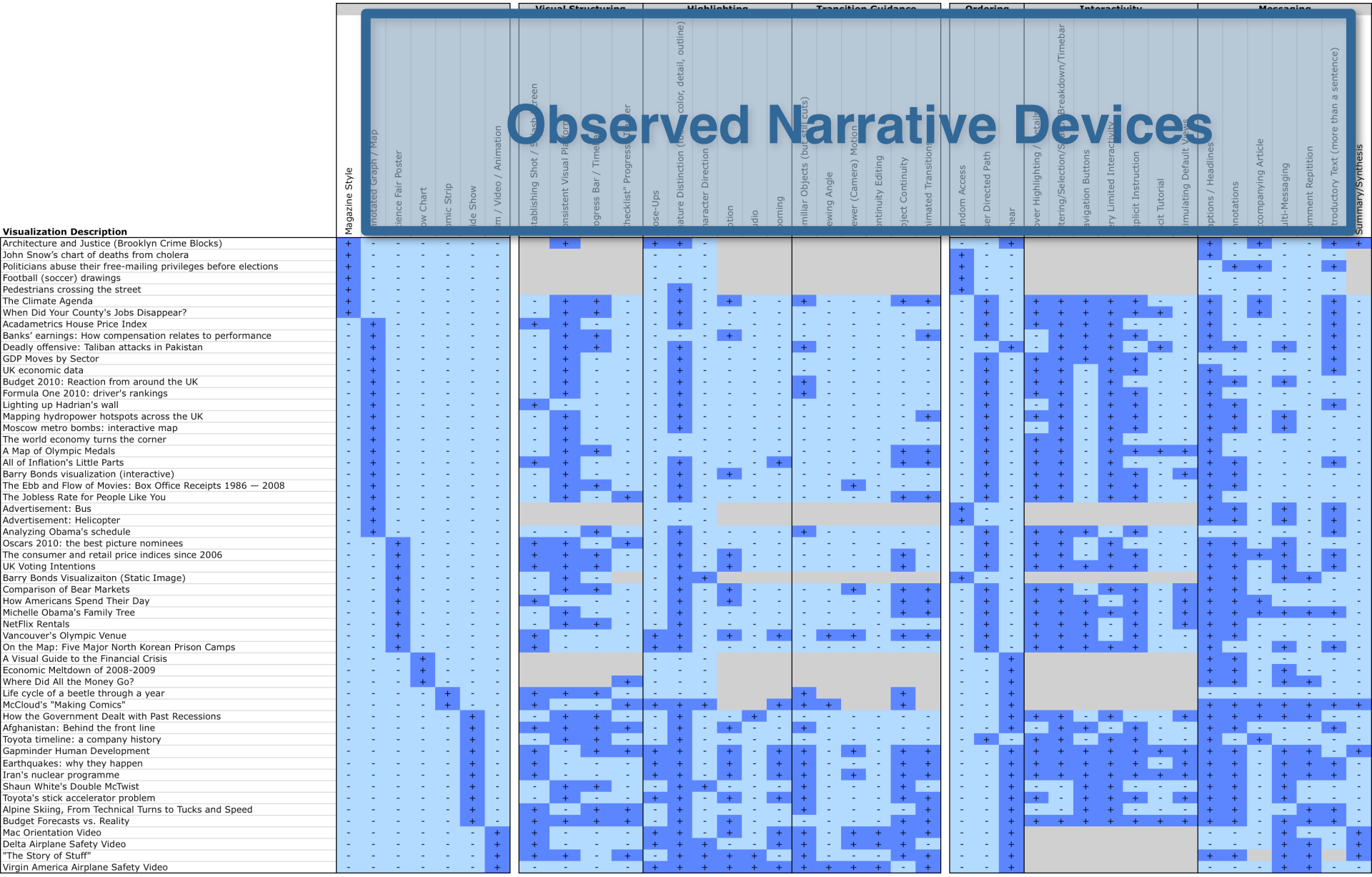
"The Story of Stuff"
Virgin America Airplane Safety Video



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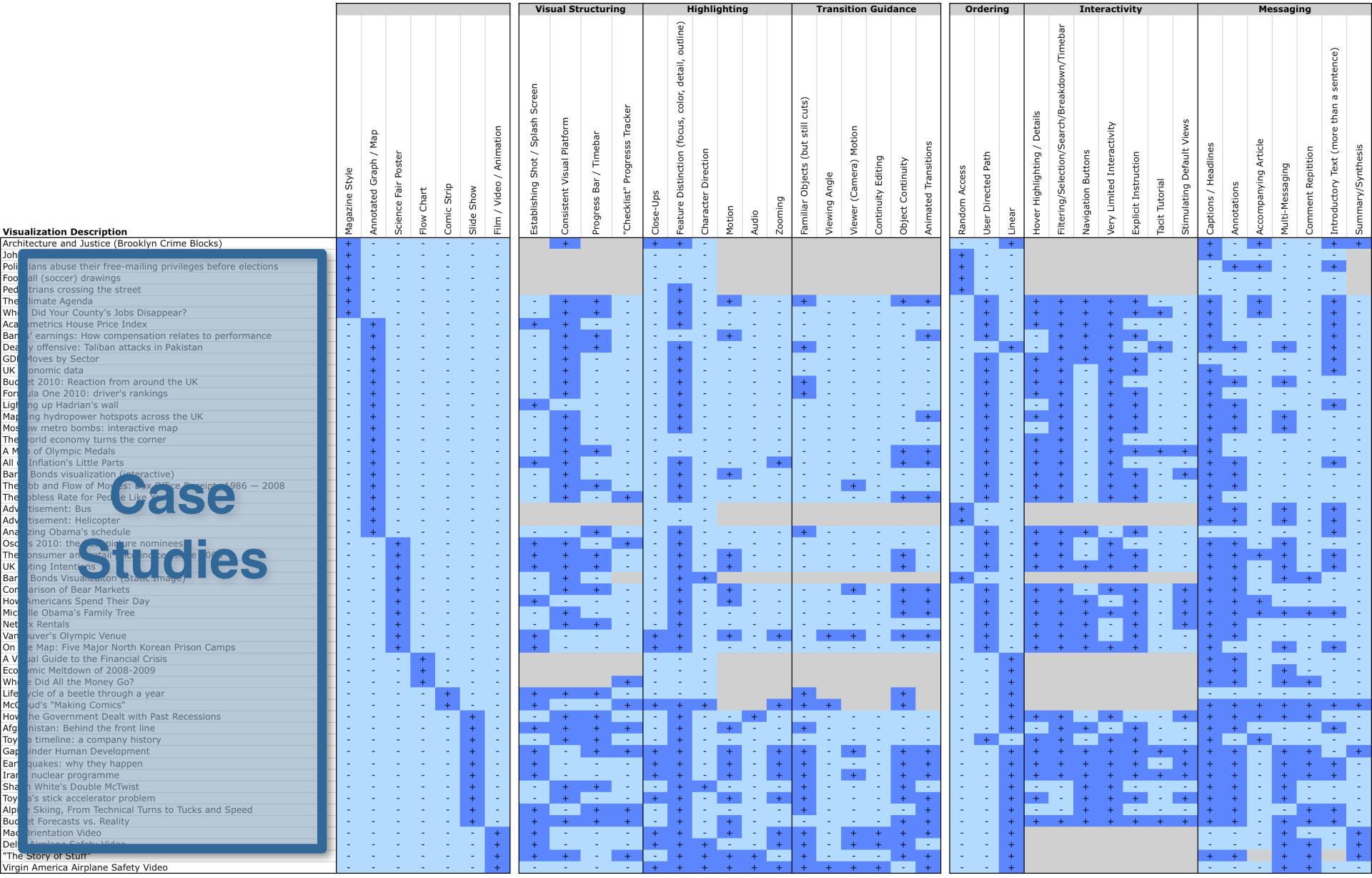
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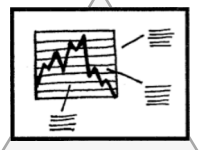
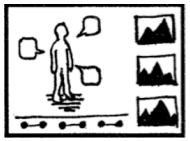
Case Studies

Visual Design

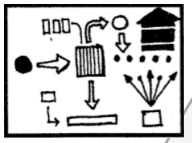
MAGAZINE STYLE



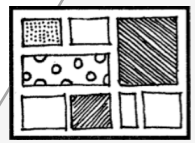
ANNOTATED CHART



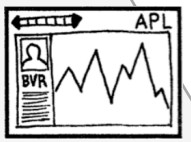
SCIENCE FAIR POSTER



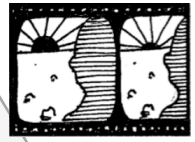
FLOWCHART



COMICSTRIP



SLIDESHOW



MOVIE

Duo-Specific

Captions

Annotations

Attached Article

Summaries

Interpret

Headlines

Tacit Tutorial

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Navigation

Details on Demand

Timelines

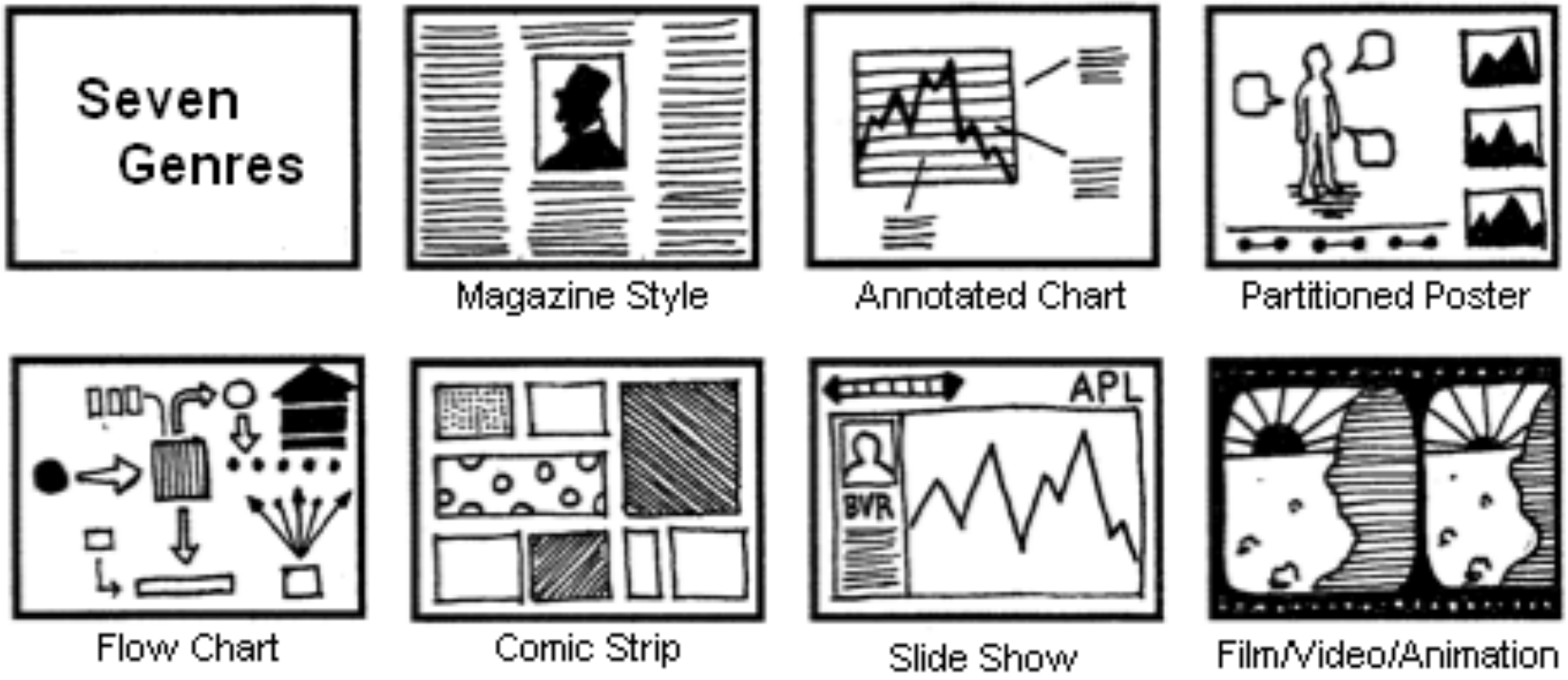
Filtering

Highlighting

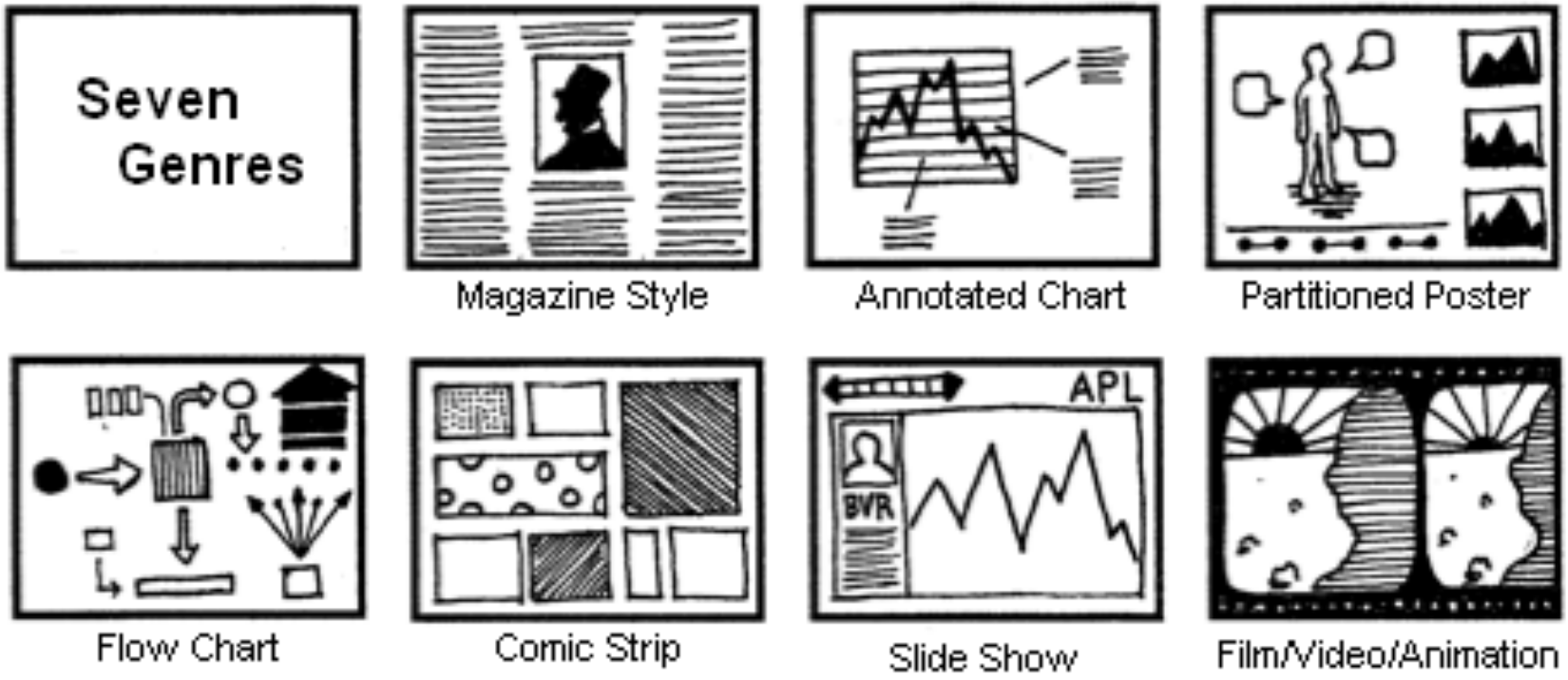
Messaging

Interactivity

MORE



Genres for Narrative Visualization (2010)



Genres for Narrative Visualization (2010)

Missing "scrolly-telling" designs…

Genres + Interactivity + Messaging =

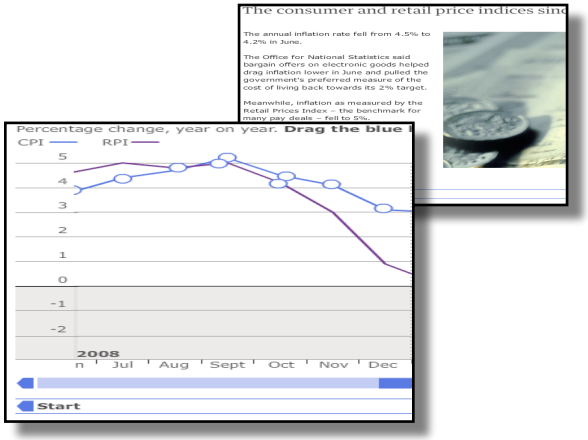
DESIGN SPACE

STORYTELLING	**Author Driven** strong ordering heavy messaging limited interactivity	**Reader Driven** weak ordering light messaging free interactivity
CLARITY		
SPEED		

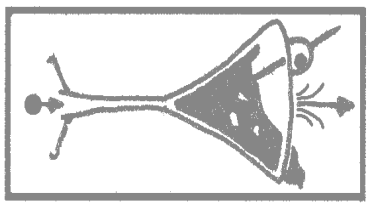
ASK QUESTIONS

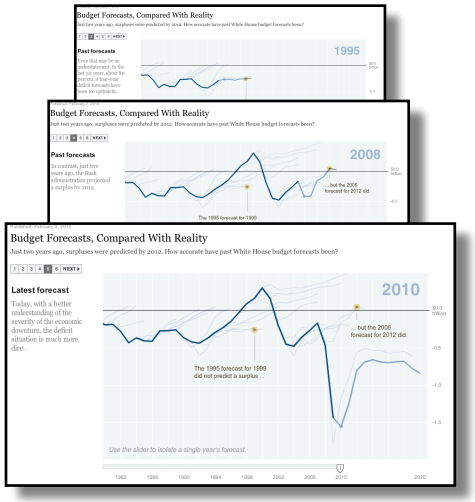
EXPLORE

FIND

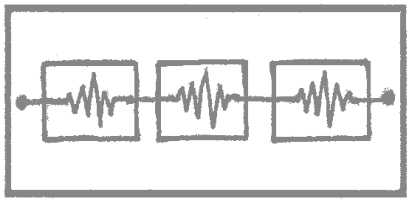


martini glass

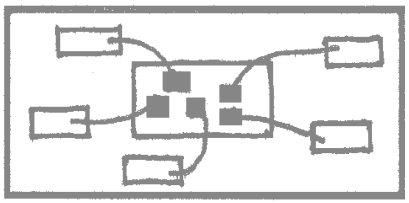




interactive slideshow



drill-down story



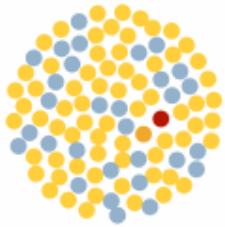
Other techniques: simulation, games, rhetorical, draw the trend

Watch how the measles outbreak spreads when kids get vaccinated – and when they don't

vaccinated · susceptible · vaccinated but susceptible · infected · contact with an infected person

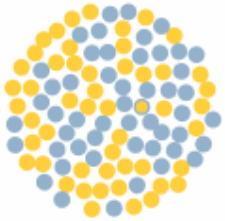
NOT PROTECTED

10.0% vax rate

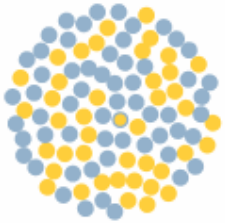


NOT PROTECTED

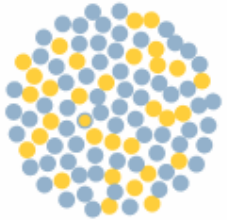
30.0% vax rate



50.0% vax rate

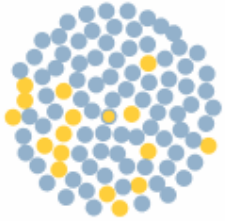


58.5% vax rate, similar to **Okanagan County, WA**

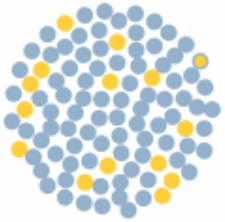


68.9% vax rate, similar to **Thurston County, WA**

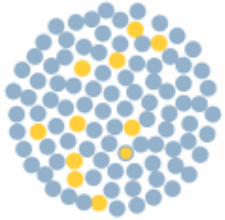
74.4% vax rate, similar to **Island County, WA**



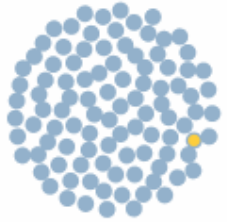
83.8% vax rate, similar to **Santa Cruz County, CA**



86.0% vax rate, similar to **Los Angeles County, CA**



90.0% vax rate, similar to **Orange County, CA**



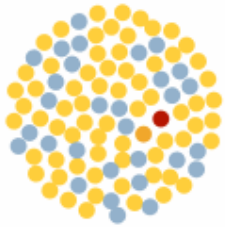
99.7% vax rate, similar to **Gadsden County, FL**

Watch how the measles outbreak spreads when kids get vaccinated – and when they don't

vaccinated · susceptible · vaccinated but susceptible · infected · contact with an infected person

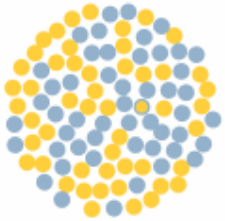
NOT PROTECTED

10.0% vax rate

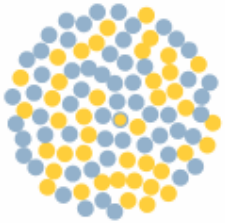


NOT PROTECTED

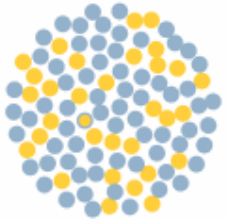
30.0% vax rate



50.0% vax rate

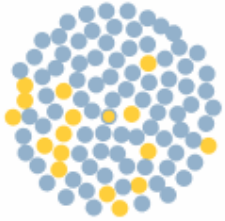


58.5% vax rate, similar to **Okanagan County, WA**

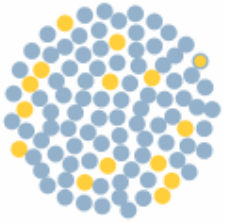


68.9% vax rate, similar to **Thurston County, WA**

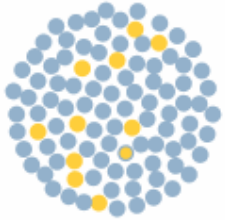
74.4% vax rate, similar to **Island County, WA**



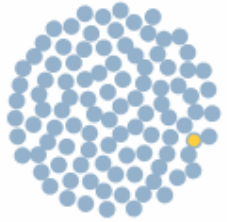
83.8% vax rate, similar to **Santa Cruz County, CA**



86.0% vax rate, similar to **Los Angeles County, CA**



90.0% vax rate, similar to **Orange County, CA**



99.7% vax rate, similar to **Gadsden County, FL**

Who Should Get Parole?

Even the best risk assessments yield probabilities, not certainties. That means they label as "high risk" some people who won't commit another crime and label as "low risk" some people who will. This simulation lets you sort offenders into risk categories based on the results of an assessment. Think we should rarely lock up anyone who wouldn't reoffend? Set the "low risk" threshold high and the "high risk" threshold even higher. Have little tolerance for recidivism? Try the opposite. In the real world, policymakers have to strike a balance. Read more »

1

The prisoners in this simulation are up for parole. Some will reoffend if released and some won't. They each take an assessment, which estimates the chance they will reoffend.

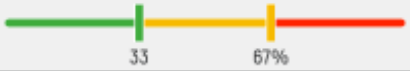
Stop

PAROLE-ELIGIBLE PRISONERS

● - Will reoffend
○ - Will not reoffend

2

Prisoners are placed in one of three categories based on these estimates. **Move the slider** to change the cutoffs for each category. "Low risk" prisoners will be awarded parole. "High risk" prisoners will be denied.



LOW RISK

MEDIUM RISK

HIGH RISK

3

Some people you let out reoffended. Some people you left in prison wouldn't have. **Are you OK with the results?**

AWARDED PAROLE

18%
AWARDED PAROLE AND THEN REOFFENDED

DENIED PAROLE

14%
DENIED PAROLE BUT WOULDN'T HAVE REOFFENDED

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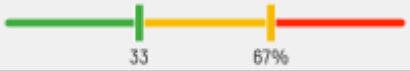

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I am female White and currently 23 years old. LIVE

AGE OF DEATH	DIED SO FAR	STILL ALIVE
23 years	1%	99%

CAUSE OF DEATH SO FAR

0%	Infection
0%	Cancer
0%	Blood
0%	Endocrine
0%	Mental
0%	Nervous
0%	Circulatory
0%	Respiratory
0%	Digestive
0%	Musculoskeletal
0%	Genitourinary
0%	Perinatal
0%	Congenital
0%	External Causes
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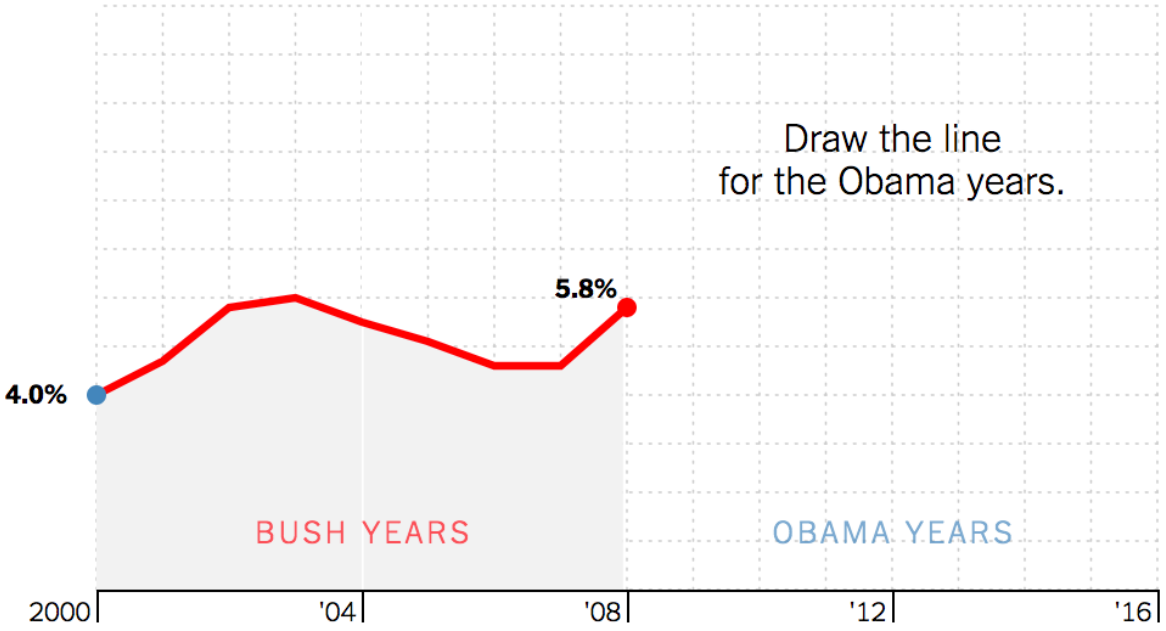
You Draw It: What Got Better or Worse During Obama's Presidency

By LARRY BUCHANAN, HAEYOUN PARK and ADAM PEARCE JAN. 15, 2017

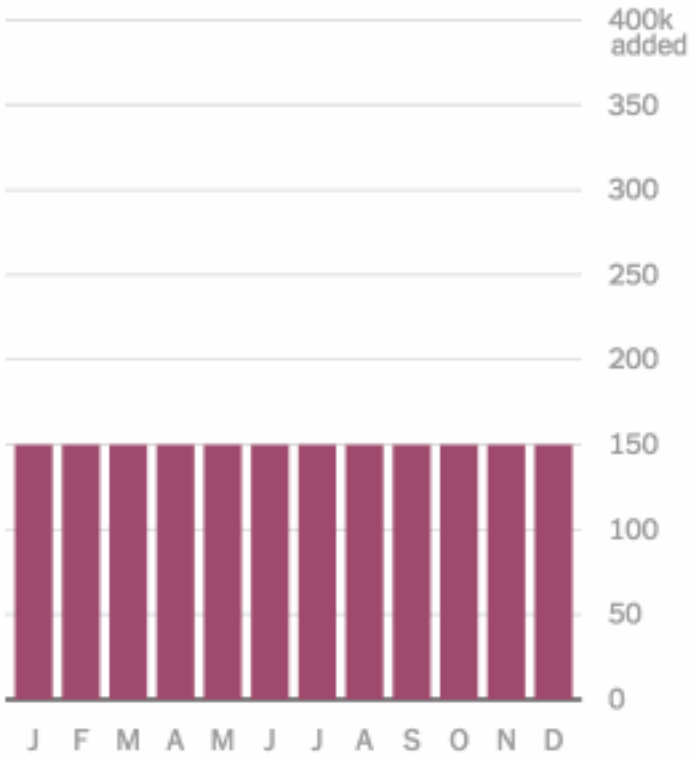
Draw your guesses on the charts below to see if you're as smart as you think you are.

Under President Obama, the **unemployment rate** ...



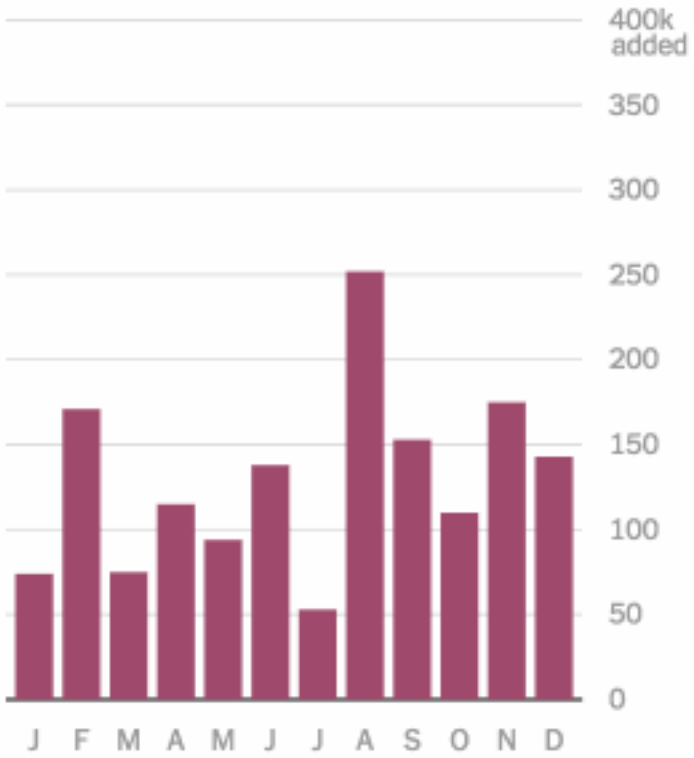
Show me how I did.

If job growth **were actually steady** over the last 12 months...



...the jobs report **could look like this**:

Pause



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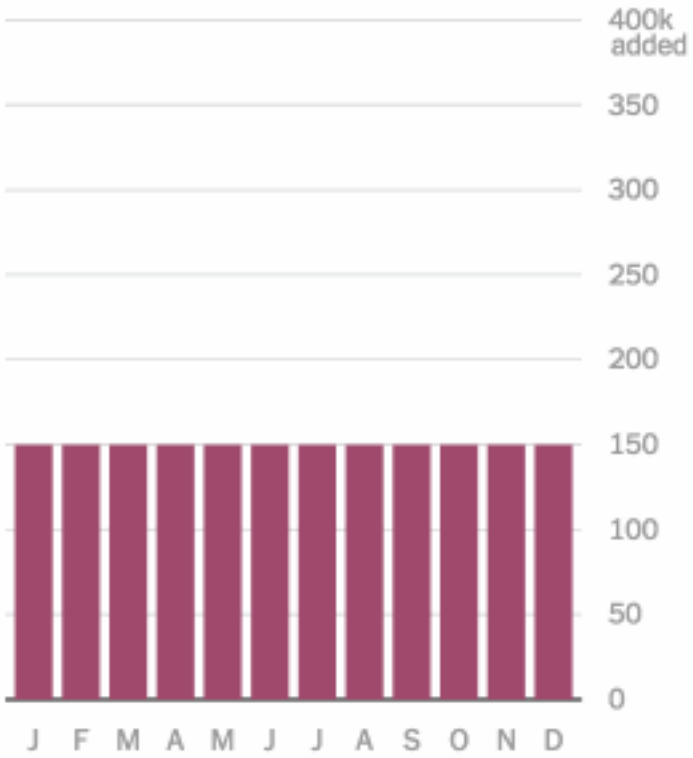

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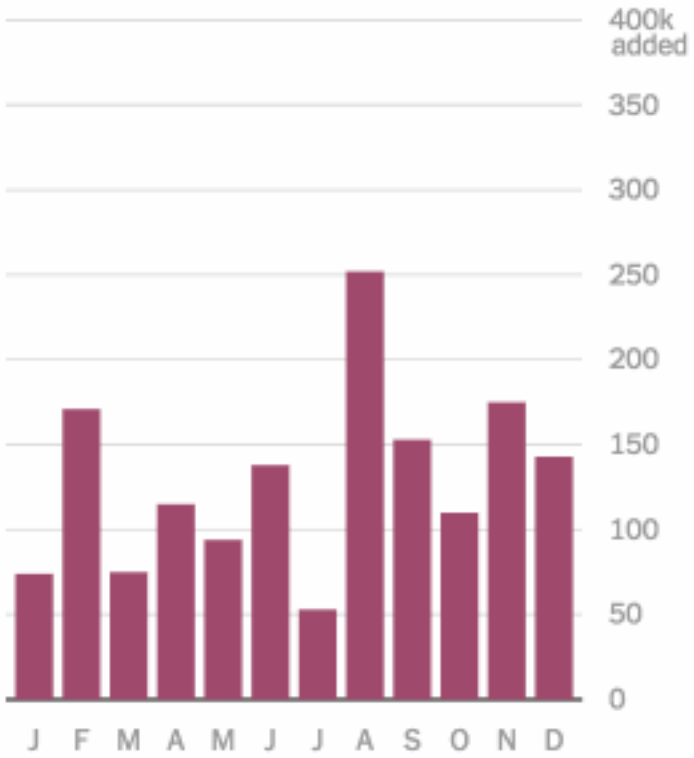

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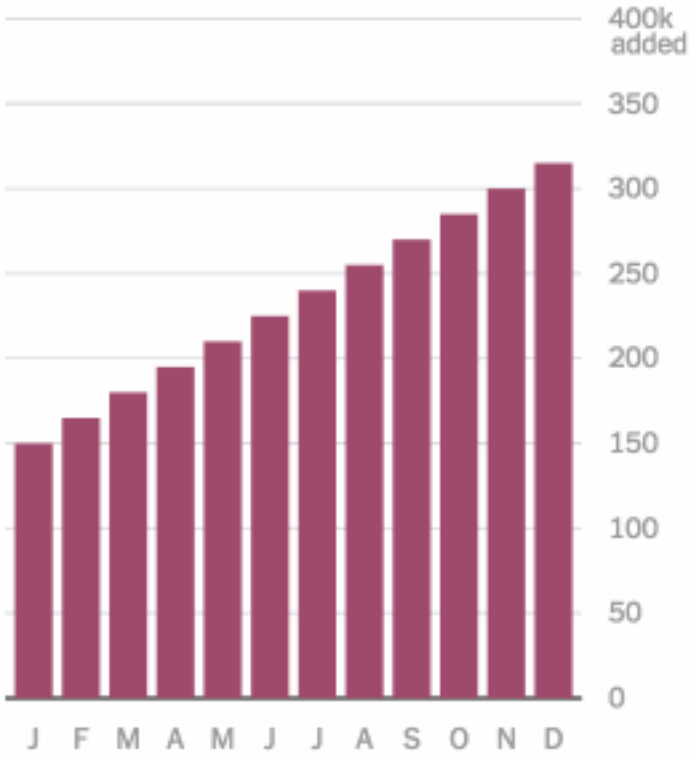

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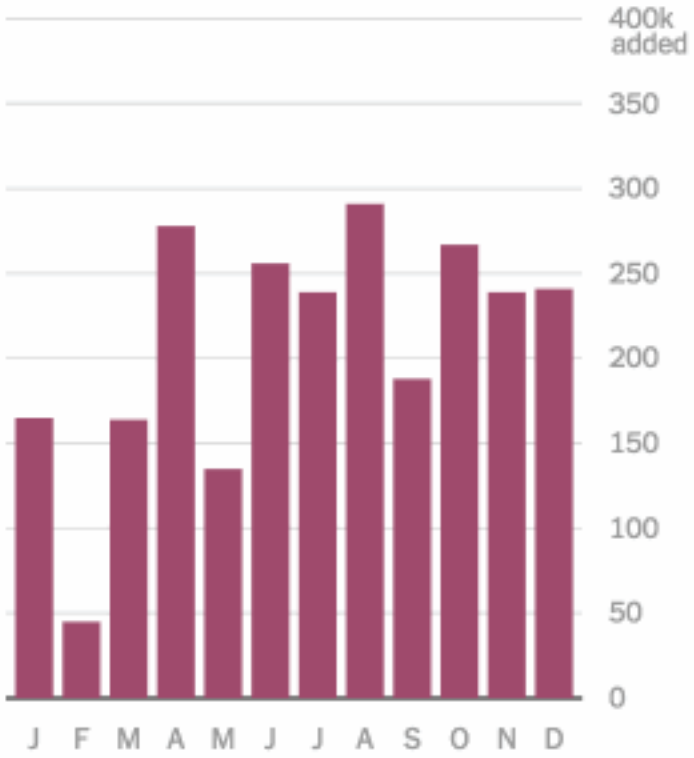
Pause



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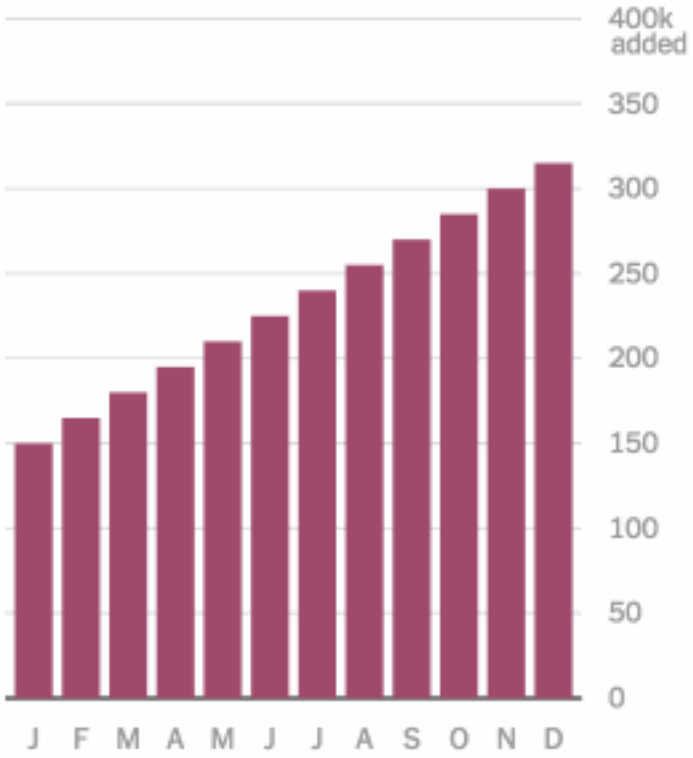

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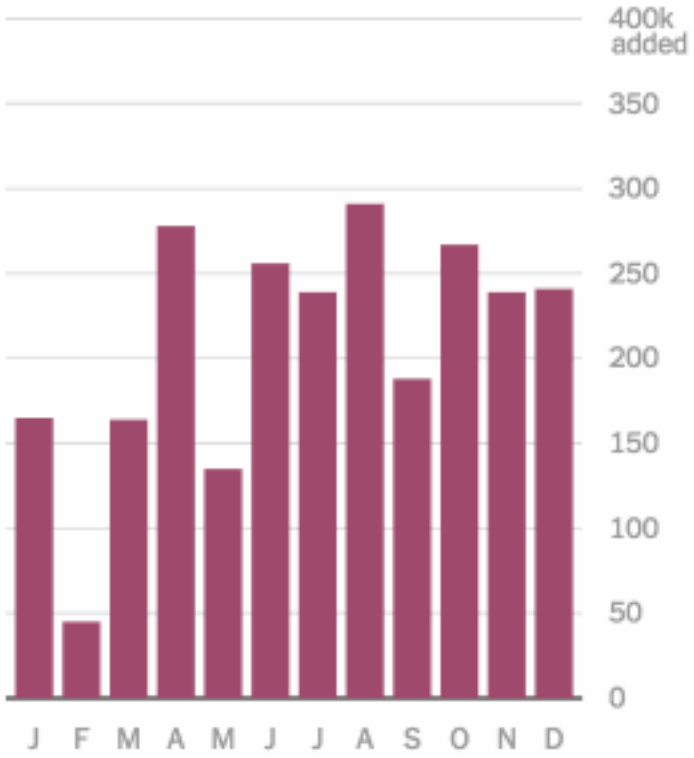


THE WALL STREET JOURNAL.

Blue Feed, Red Feed

See Liberal Facebook and Conservative Facebook, Side by Side

*By **Jon Keegan***

Published May 18, 2016 at 8:00 a.m. ET | Updated hourly

FILTER FEEDS BY TOPIC:

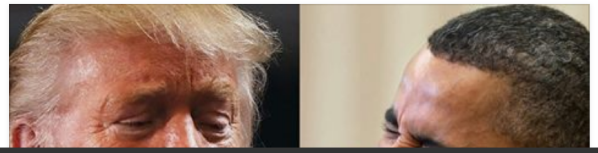
PRESIDENT TRUMP | HEALTH CARE | GUNS | ABORTION | ISIS | BUDGET | EXECUTIVE ORDER | IMMIGRATION

SHOWING POSTS ABOUT: **"HEALTH CARE"**

LIBERAL

Occupy Democrats
2 hours ago

The president thought he could undo his predecessor's legacy, but his plan isn't exactly panning out.



CONSERVATIVE

The Federalist Papers
9 hours ago

A horrible testament to what happens with government-run healthcare systems.

Interactive Documents: Steppers, Scrollers, …

Gun Deaths In America

By Ben Casselman, Matthew Conlen and Reuben Fischer-Baum

CLICK to advance

Gun Deaths In America

By Ben Casselman, Matthew Conlen and Reuben Fischer-Baum

CLICK to advance

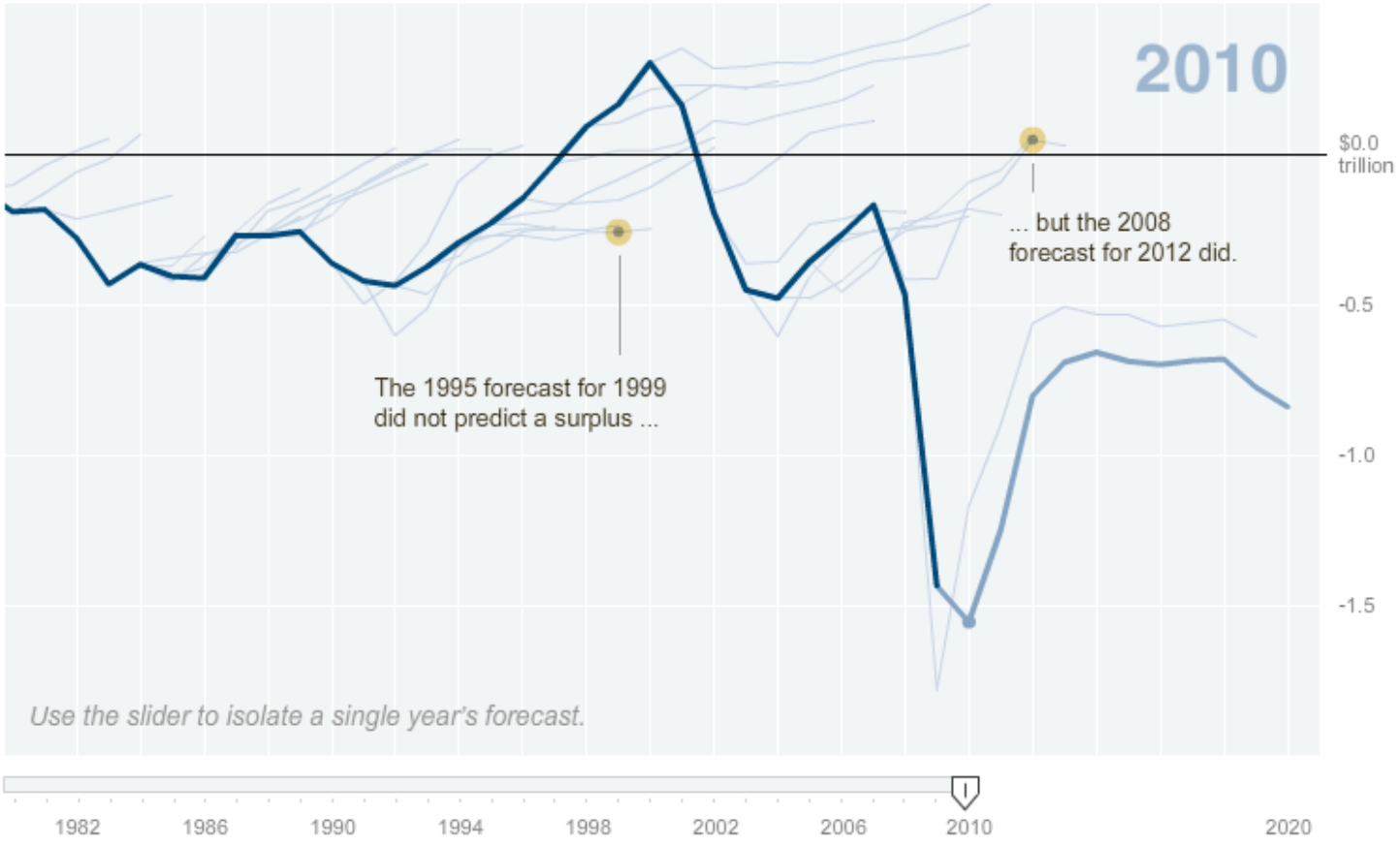
Published: February 2, 2010

Budget Forecasts, Compared With Reality

Just two years ago, surpluses were predicted by 2012. How accurate have past White House budget forecasts been?

Latest forecast

Today, with a better understanding of the severity of the economic downturn, the deficit situation is much more dire.



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1 | 2 | 3 | 4 | 5 | 6 | NEXT ▶

Stepper

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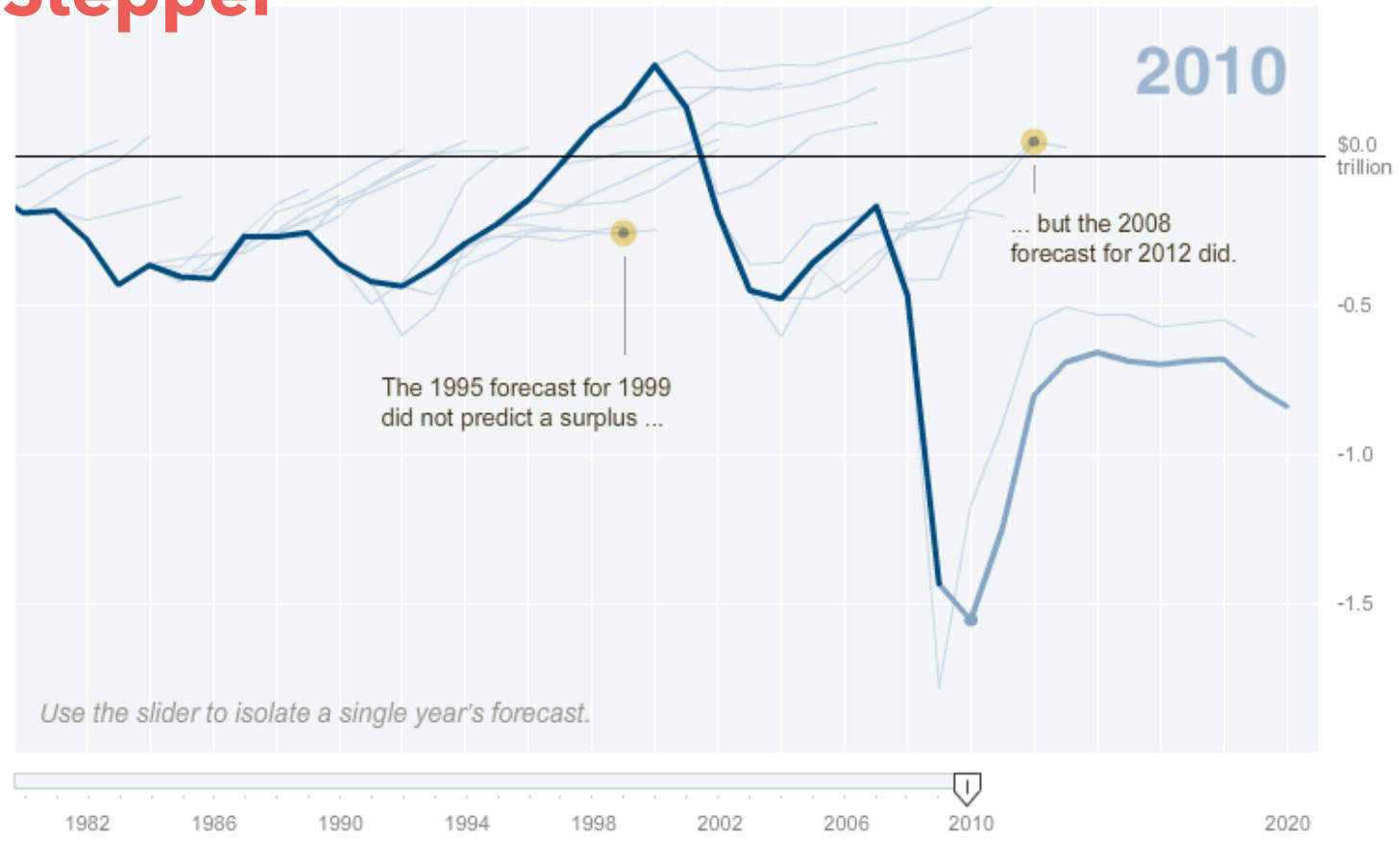


NY Times
2014

NY Times
2014

Ramadi: The Government Provides an Opening for ISIS

ISIS Control

Tensions between this city's residents, who are mostly Sunni, and the central government had been brewing here for at least a year. Then in December, Iraq's prime minister, Nuri Kamal al-Maliki, ordered security forces to dismantle a protest camp — an outlet for disenchanted Sunnis angered at their treatment by the Shiite-dominated government. The action ignited days of violence and created the opening ISIS needed to seize parts of the city, the provincial capital.

Falluja: A Symbolic Fall

ISIS Control

Just days after the raid on the camp in Ramadi, ISIS fighters destroyed the Police Headquarters and mayor's office here, planted their flag on government buildings and decreed the city to be theirs. Ten years earlier, American forces had captured this city from Qaeda-style insurgents at a considerable cost of American lives.

Scroll

Bloomberg
2015

Bloomberg
2015

Bloomberg
2015

R2
D3

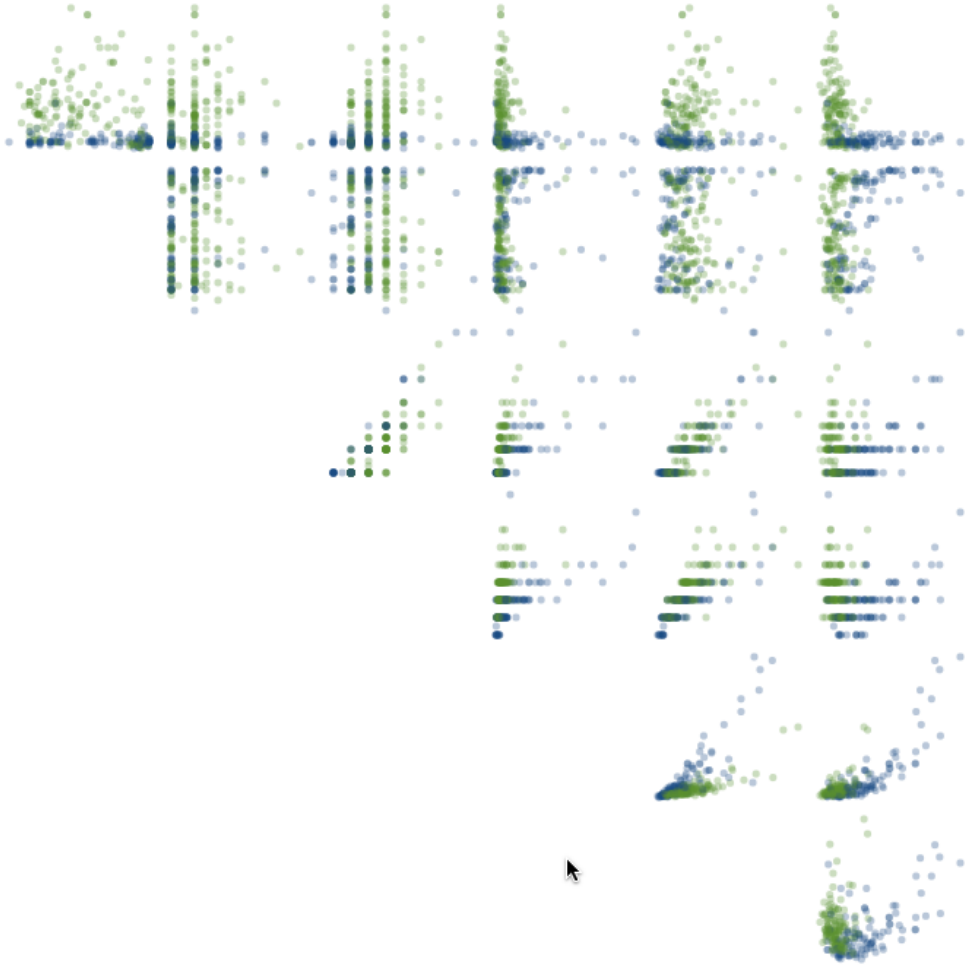
A visual introduction to machine learning

English

In machine learning, computers apply **statistical learning** techniques to automatically identify patterns in data. These techniques can be used to make highly accurate predictions.

Keep scrolling. Using a data set about homes, we will create a machine learning model to distinguish homes in New York from homes in San Francisco.

SCROLL



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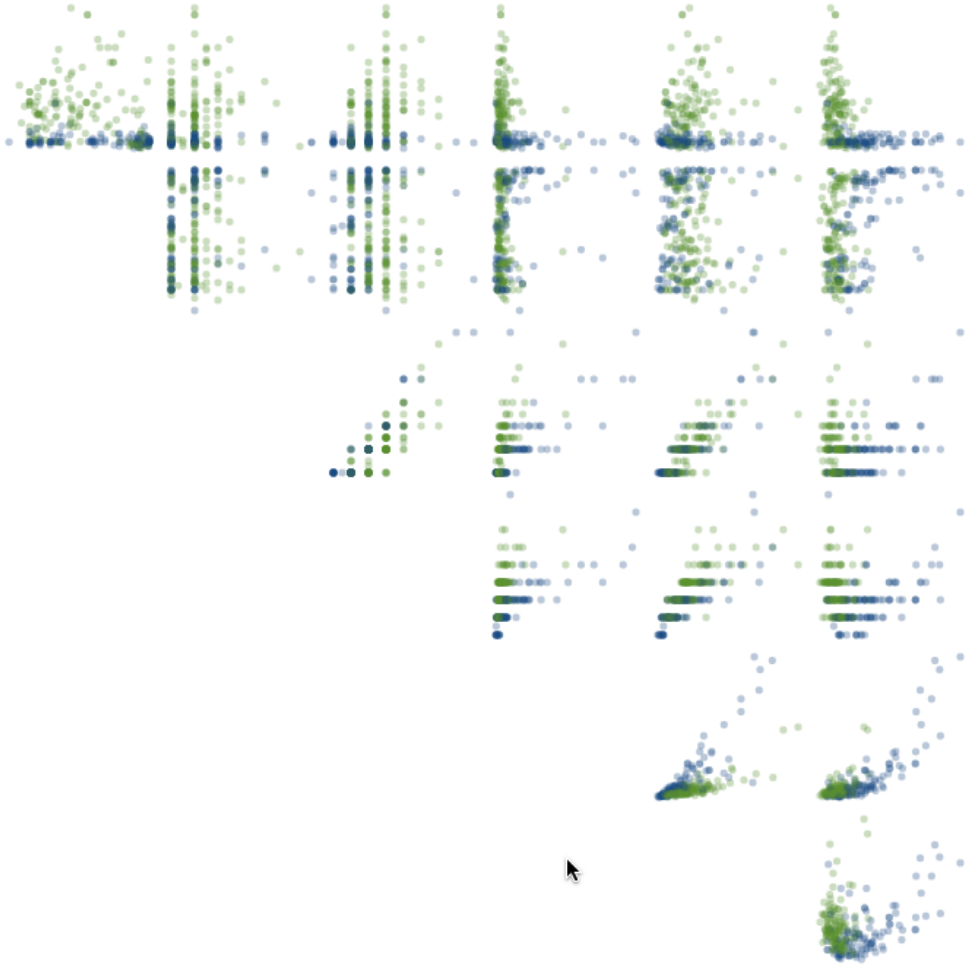

Discrete step vs. Continuous scroll

Different means for narrative navigation.
A source of debate among practitioners!

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Step: sequential frames as in a slideshow
Simple and familiar, but less engaging?

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Parameterize content by scroll position
May cause usability / scrolljacking issues

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Hybrids: scroller with discrete sections

Narrative Visualization + Science

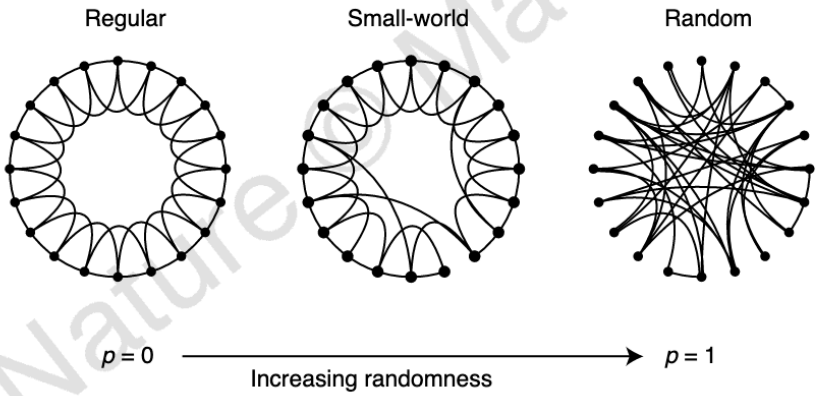

Figure 1 Random rewiring procedure for interpolating between a regular ring lattice and a random network, without altering the number of vertices or edges in the graph. We start with a ring of n vertices, each connected to its k nearest neighbours by undirected edges. (For clarity, $n = 20$ and $k = 4$ in the schematic examples shown here, but much larger n and k are used in the rest of this Letter.) We choose a vertex and the edge that connects it to its nearest neighbour in a clockwise sense. With probability p, we reconnect this edge to a vertex chosen uniformly at random over the entire ring, with duplicate edges forbidden; otherwise we leave the edge in place. We repeat this process by moving clockwise around the ring, considering each vertex in turn until one lap is completed. Next, we consider the edges that connect vertices to their second-nearest neighbours clockwise. As before, we randomly rewire each of these edges with probability p, and continue this process, circulating around the ring and proceeding outward to more distant neighbours after each lap, until each edge in the original lattice has been considered once. (As there are $nk/2$ edges in the entire graph, the rewiring process stops after $k/2$ laps.) Three realizations of this process are shown, for different values of p. For $p = 0$, the original ring is unchanged; as p increases, the graph becomes increasingly disordered until for $p = 1$, all edges are rewired randomly. One of our main results is that for intermediate values of p, the graph is a small-world network: highly clustered like a regular graph, yet with small characteristic path length, like a random graph. (See Fig. 2.)

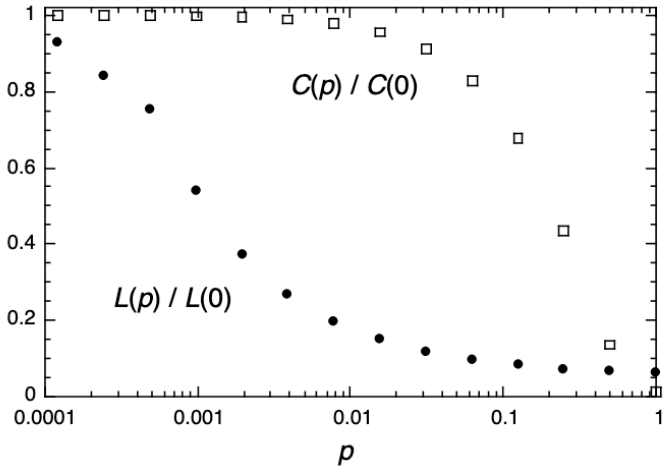

Figure 2 Characteristic path length $L(p)$ and clustering coefficient $C(p)$ for the family of randomly rewired graphs described in Fig. 1. Here L is defined as the number of edges in the shortest path between two vertices, averaged over all pairs of vertices. The clustering coefficient $C(p)$ is defined as follows. Suppose that a vertex v has k_v neighbours; then at most $k_v(k_v - 1)/2$ edges can exist between them (this occurs when every neighbour of v is connected to every other neighbour of v). Let C_v denote the fraction of these allowable edges that actually exist. Define C as the average of C_v over all v. For friendship networks, these statistics have intuitive meanings: L is the average number of friendships in the shortest chain connecting two people; C_v reflects the extent to which friends of v are also friends of each other; and thus C measures the cliquishness of a typical friendship circle. The data shown in the figure are averages over 20 random realizations of the rewiring process described in Fig. 1, and have been normalized by the values $L(0)$, $C(0)$ for a regular lattice. All the graphs have $n = 1{,}000$ vertices and an average degree of $k = 10$ edges per vertex. We note that a logarithmic horizontal scale has been used to resolve the rapid drop in $L(p)$, corresponding to the onset of the small-world phenomenon. During this drop, $C(p)$ remains almost constant at its value for the regular lattice, indicating that the transition to a small world is almost undetectable at the local level.

Watts & Strogatz, 98

Collective dynamics of 'small-world' networks

Duncan J. Watts* & Steven H. Strogatz
Department of Theoretical and Applied Mechanics, Kimball Hall, Cornell University, Ithaca, New York 14853, USA

ABSTRACT **Networks of coupled dynamical systems** have been used to model biological oscillators, Josephson junction arrays, excitable media, neural networks, spatial games, genetic control networks and many other self-organizing systems. Ordinarily, the connection topology is assumed to be either **completely regular or completely random**. But many biological, technological and social networks lie somewhere **between these two extremes**.

Here we explore simple models of networks that can be tuned through this middle ground: **regular networks 'rewired'** to introduce increasing amounts of disorder. We find that these systems can be highly clustered, like regular lattices, yet have small characteristic path lengths, like random graphs. We call them **'small-world' networks**, by analogy with the small-world phenomenon (popularly known as six degrees of separation). The neural network of the worm *Caenorhabditis elegans*, the power grid of the western United States, and the collaboration graph of film actors are shown to be small-world networks.

Models of dynamical systems with small-world coupling display enhanced signal-propagation speed, computational power, and synchronizability. In particular, infectious diseases spread more easily in small-world networks than in regular lattices.

ALGORITHM To interpolate between regular and random networks, we consider the following random rewiring procedure.

We start with a ring of n vertices

where each vertex is connected to its k nearest neighbors

like so.

We choose a vertex, and the edge to its nearest clockwise neighbour.

With probability p, we reconnect this edge to a vertex chosen uniformly at random over the entire ring, with duplicate edges forbidden. Otherwise, we leave the edge in place.

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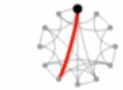

We continue this process, circulating around the ring and proceeding outward to more distant neighbours after each lap, until each original edge has been considered once.

As there are $nk/2$ edges in the entire graph, the rewiring process stops after $k/2$ laps.

For $p = 0$, the ring is unchanged.

As p increases, the graph becomes increasingly disordered.

At $p = 1$, all edges are rewired randomly.

This construction allows us to 'tune' the graph between regularity ($p = 0$) and disorder ($p = 1$), and thereby to probe the intermediate region $0 < p < 1$, about which little is known.

Victor, 2011

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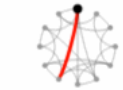

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https://distill.pub/2017/momentum/

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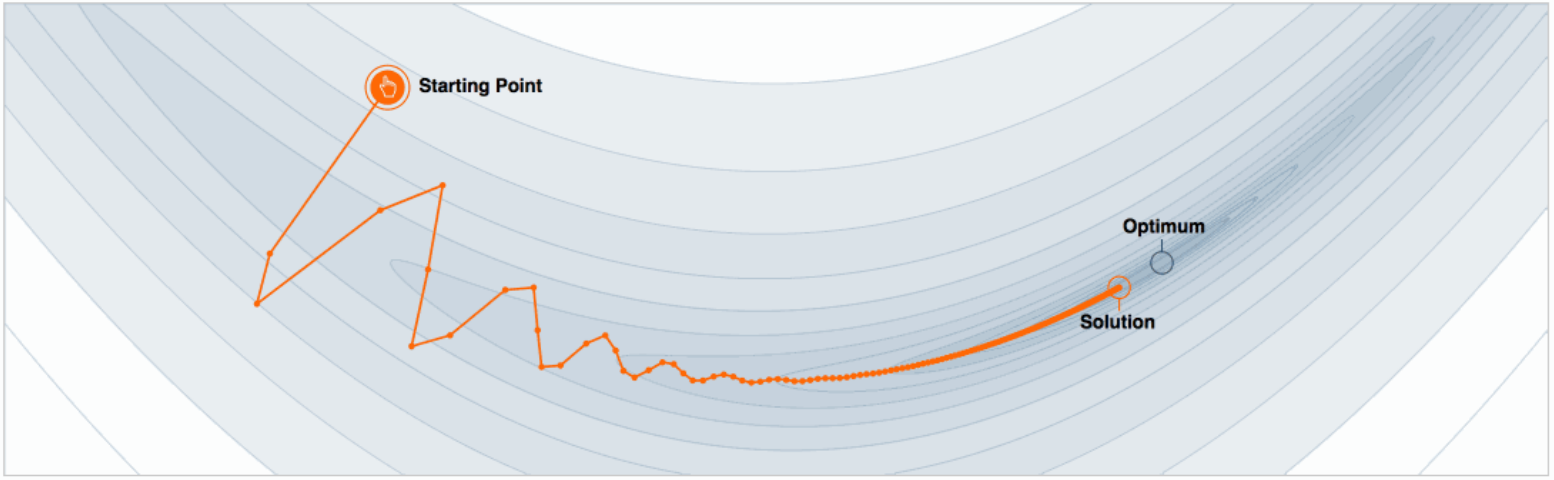
ABOUT PRIZE SUBMIT

Why Momentum Really Works



Step-size α = 0.0027

Momentum β = 0.99

We often think of Momentum as a means of dampening oscillations and speeding up the iterations, leading to faster convergence. But it

distill.pub

Graphics driven ML journal

https://distill.pub/2017/momentum/

Distill

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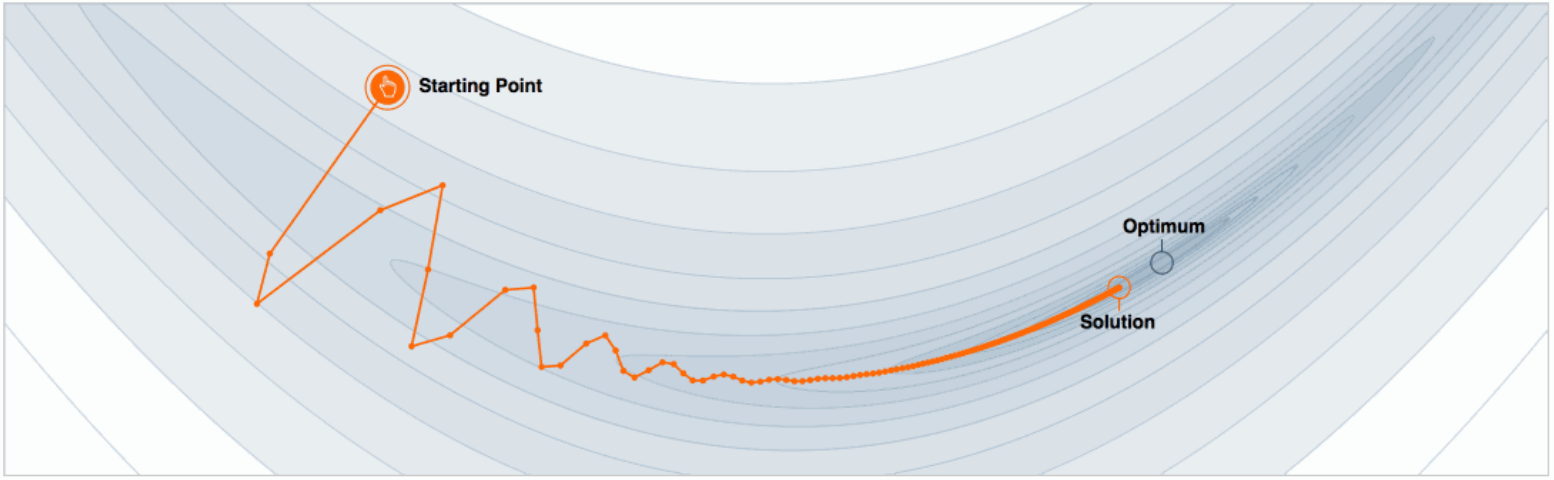

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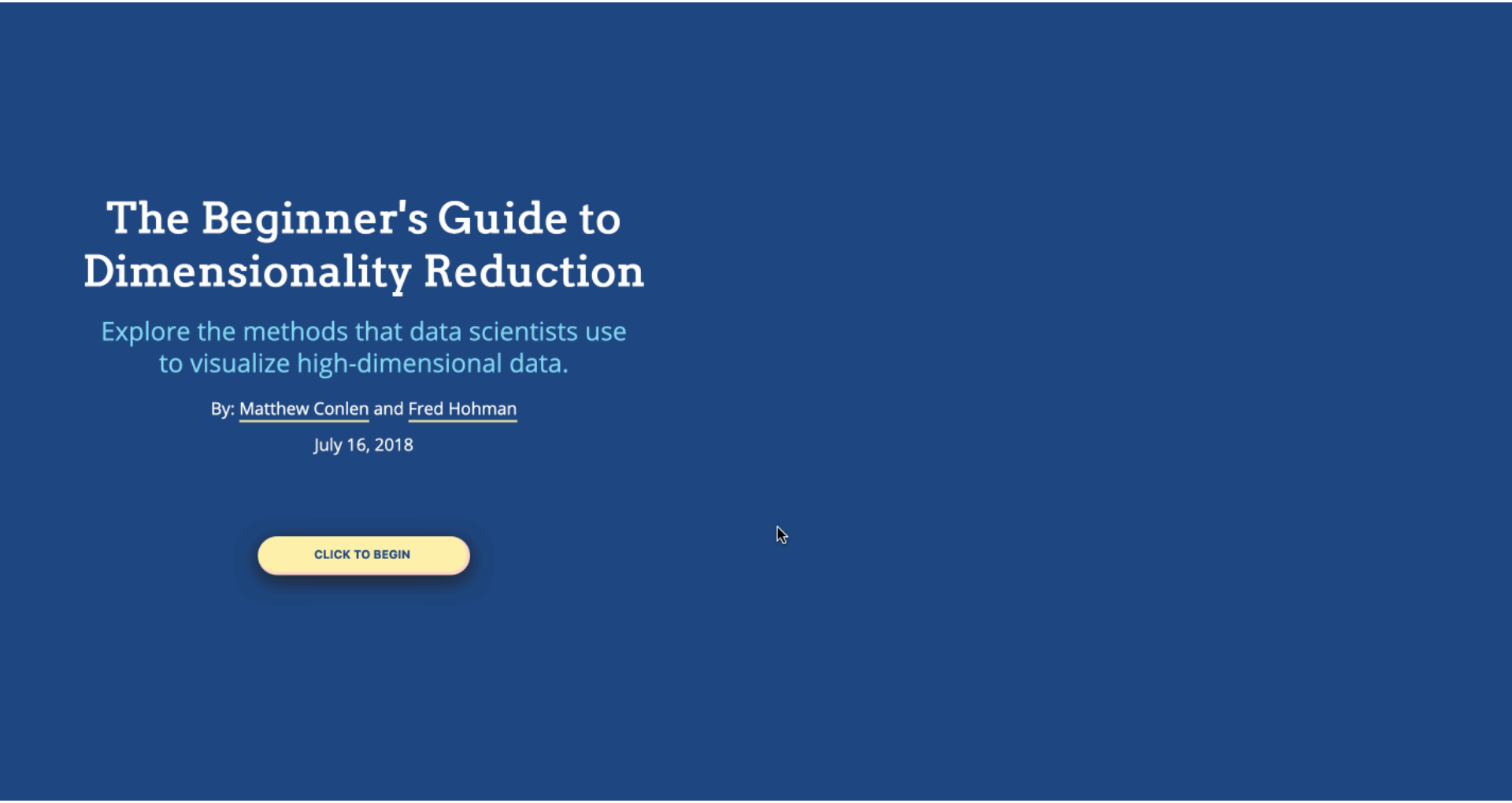
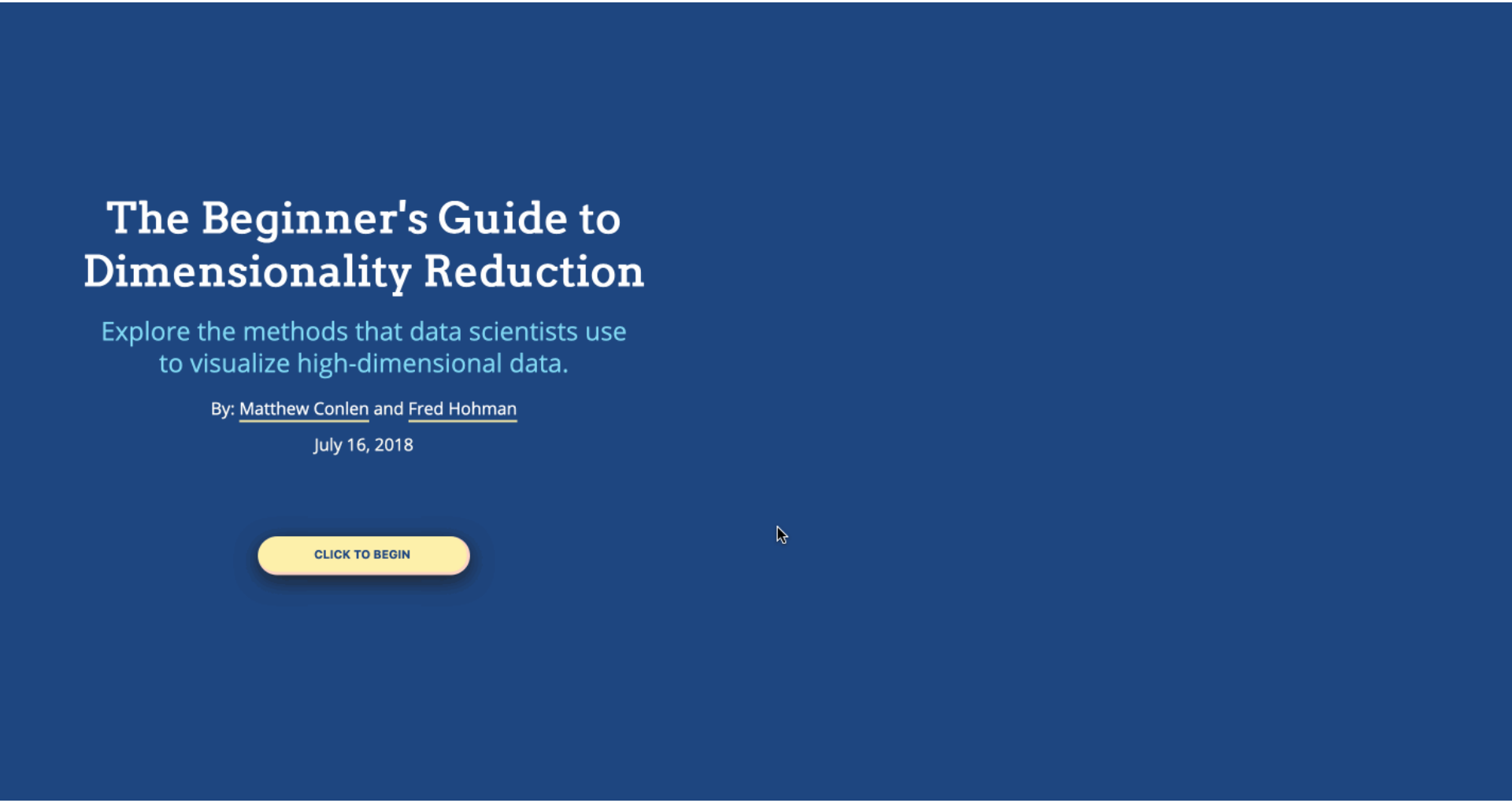


Conlen & Hohman, VisXAi 2018



Conlen & Hohman, VisXAi 2018

Explorable Multiverse Analysis

Demo

Administrative Break

Administrative Break

"Encore" D3 tutorial today!
3:30p Gates 371

Observable notebook from the tutorial is available on course site.

Narrative Implementation

Do-It-Yourself

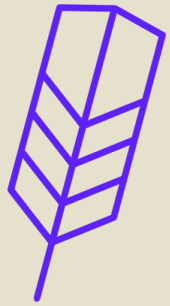
Monitor scroll position & element positions

Guidance: M. Bostock, J. Vallandingham

Third-Party Support

Helper Libraries

Interactive Document Formats: Idyll



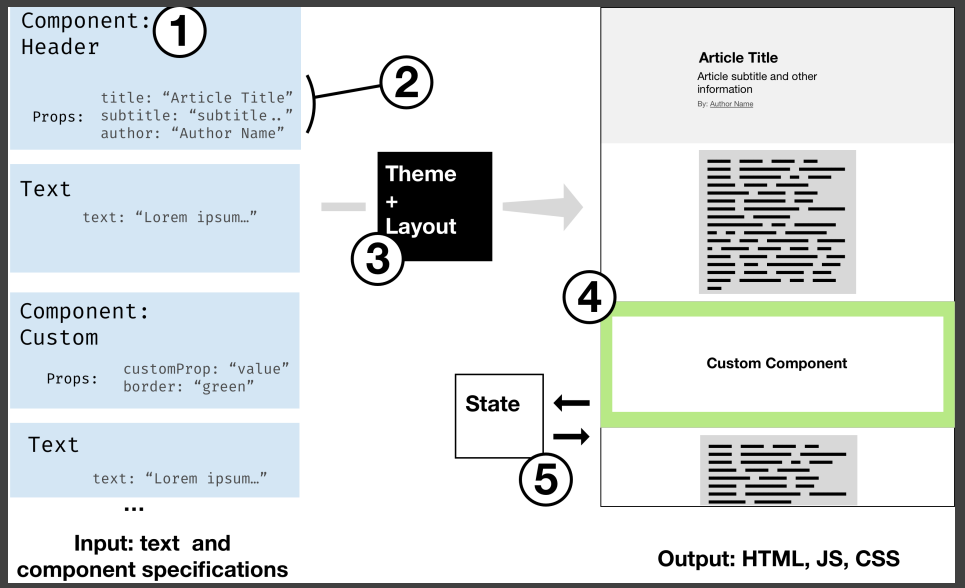
idyll

A toolkit for creating data-driven stories and explorable explanations.

Overview

Overview

Document model for interactive articles



Overview

Document model for interactive articles

Markdown-based specification language

```
[var name:"x" value:5 /]

# Hello World

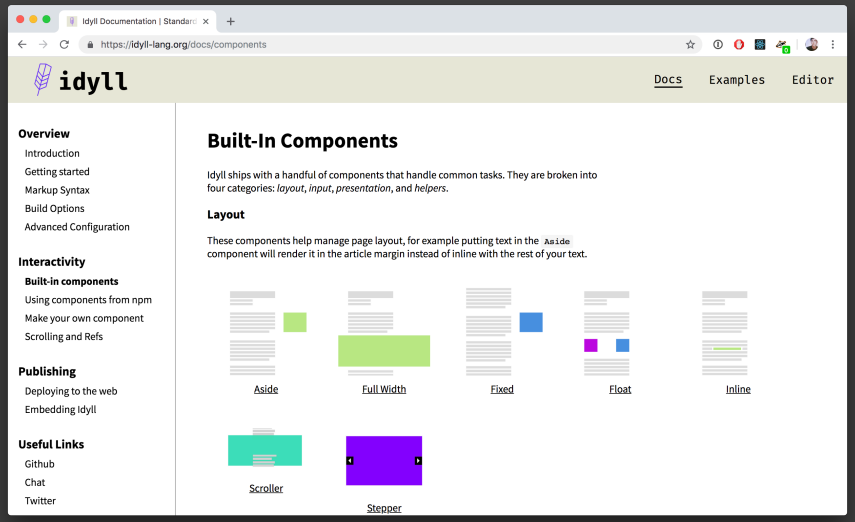
The value of x is
[Display value:x format:"d" /].
```

Overview

Document model for interactive articles

Markdown-based specification language

Component library supporting common needs



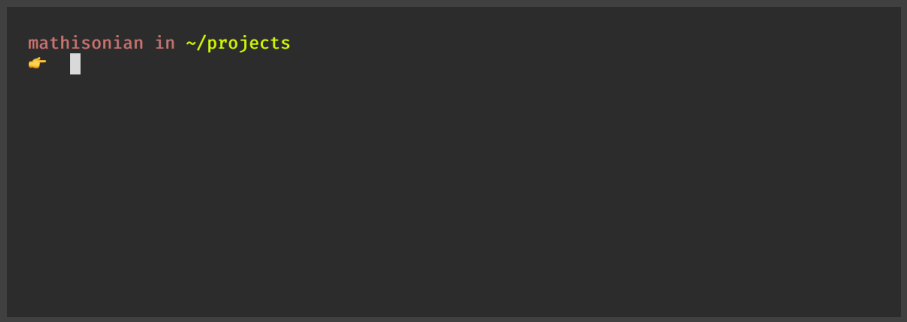
Overview

Document model for interactive articles

Markdown-based specification language

Component library supporting common needs

Suite of build, runtime, and deployment tools



In action…

```
[section]

  # A Sad Guitar.

  Take a second and strum the guitar. It doesn't sound
  so good, does it?

  We've just taken it out of storage and *it's all out of tune...*

[/section]

[section onEnterViewFully:`guitarState = 'headstock'; playScale = false;`]

  # Electric Tuner to the Rescue.

  Tune the guitar using the tuner. Click and drag the tuning
  knobs on the right to tighten and loosen the strings.
  // Need a reward state to let them know when a string is in tune

  [Tuner selectedString:targetString currFreq:currentFrequency /]

  [conditional if:isInTune]
  Great work, scroll on.
  [/conditional]

[/section]
```

In action…

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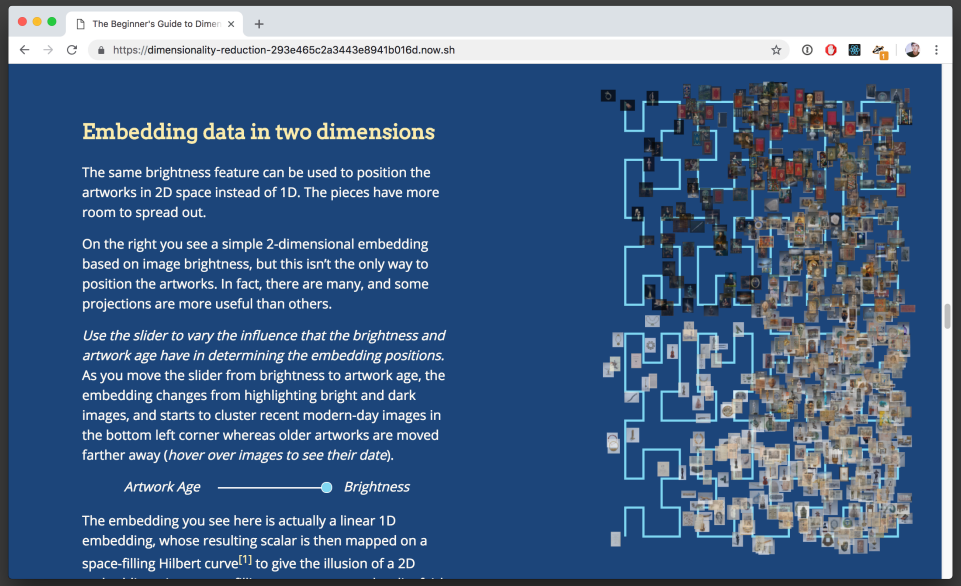
```

Evaluating Interactive Articles

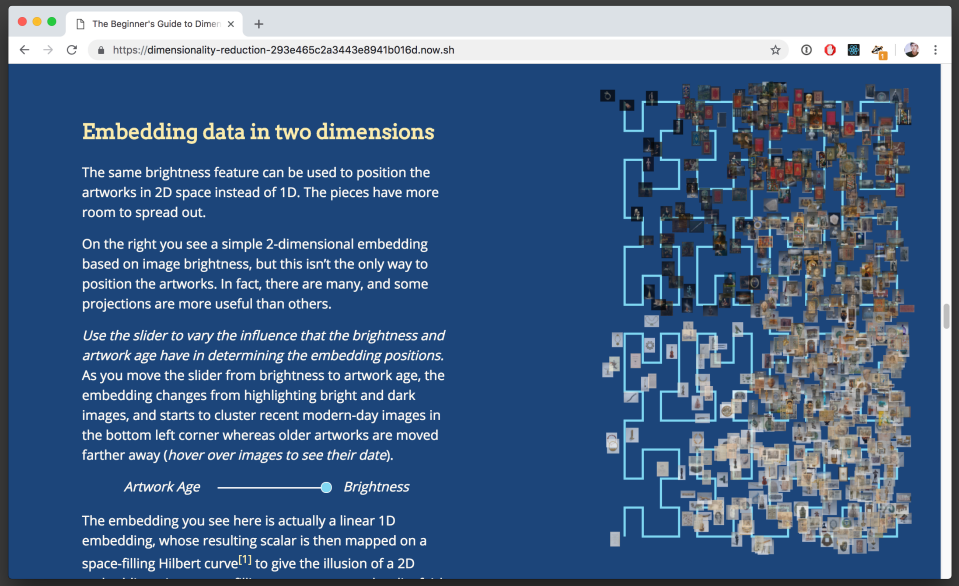
Research from education and journalism suggests interactives are effective for conveying complex topics to a wide audience.

But more data needed!

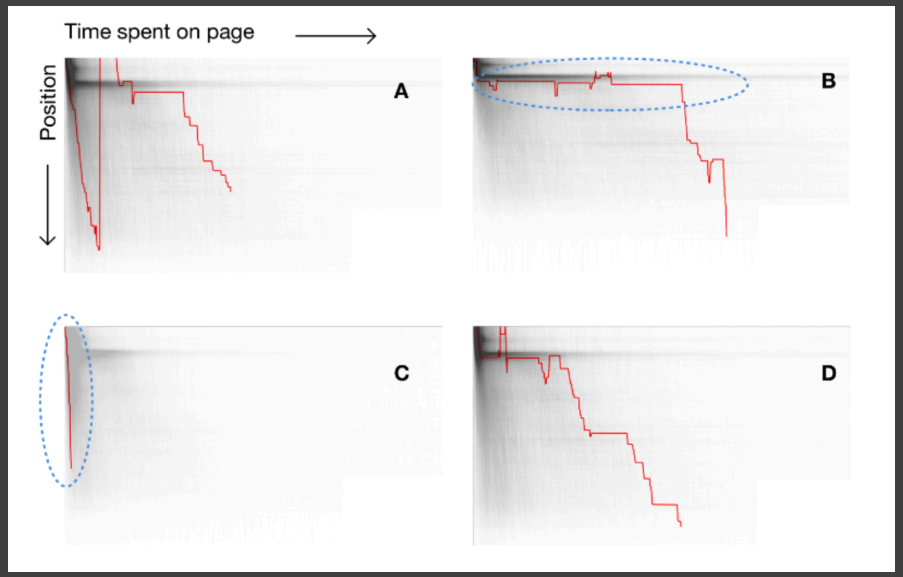


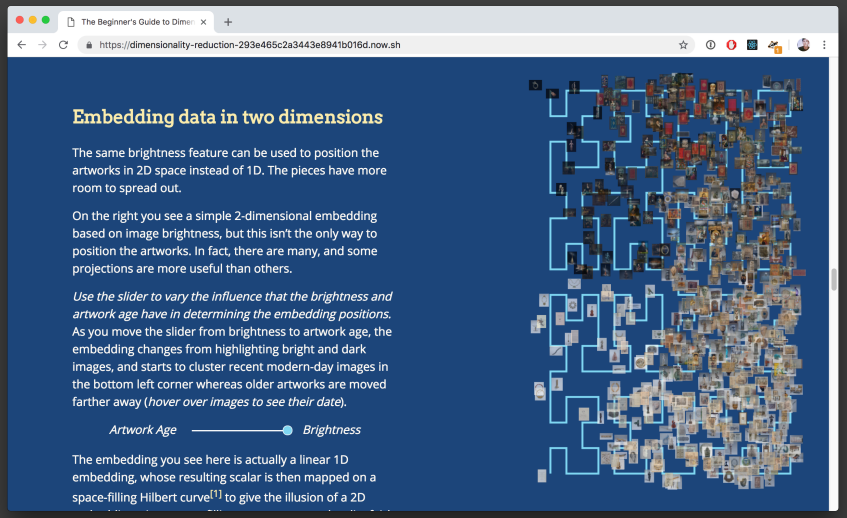
Evaluating Interactive Articles

Instrumented articles created with Idyll, recorded >50k user sessions

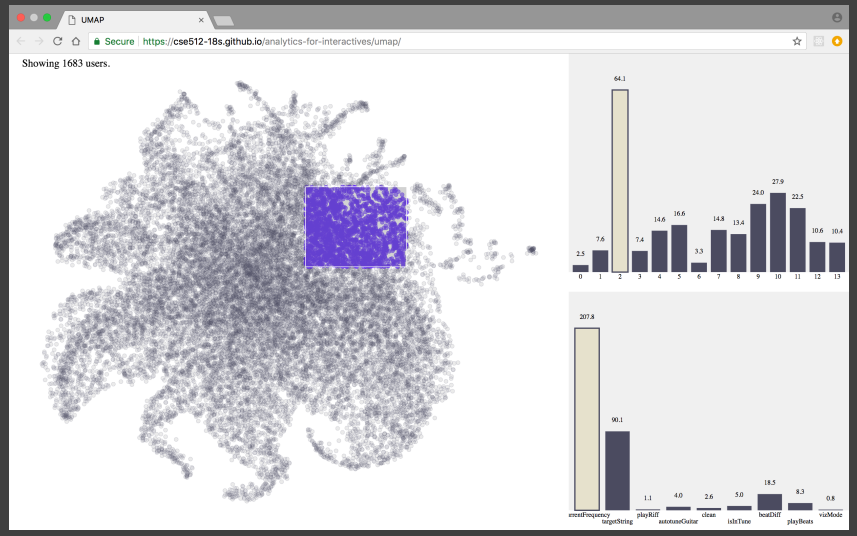


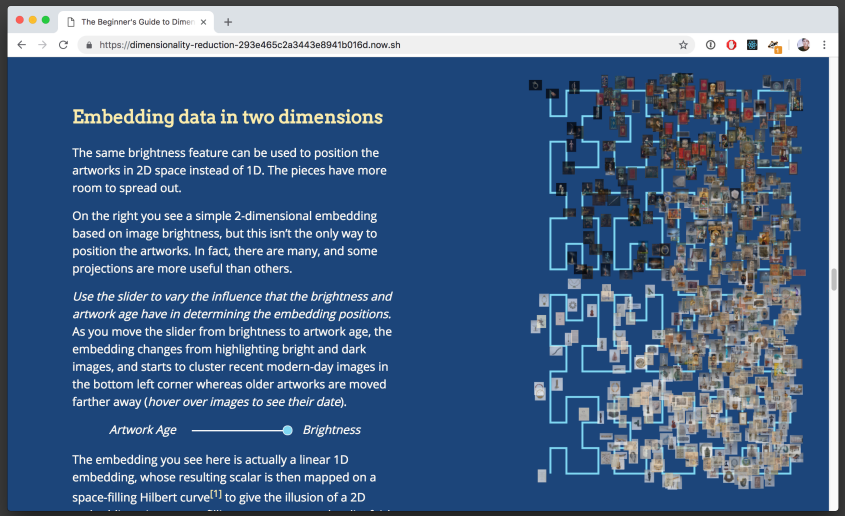
Evaluating Interactive Articles





Evaluating Interactive Articles





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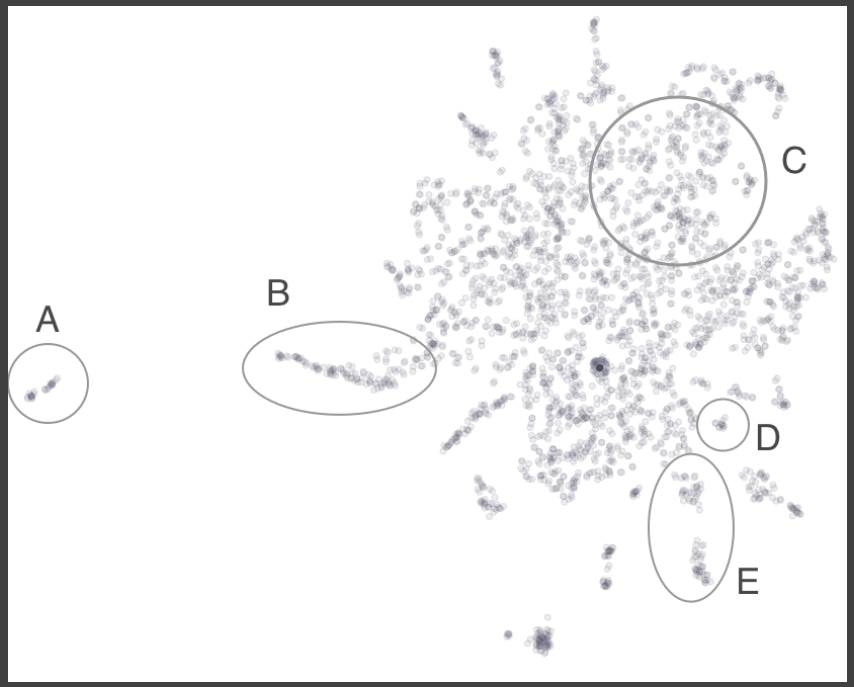


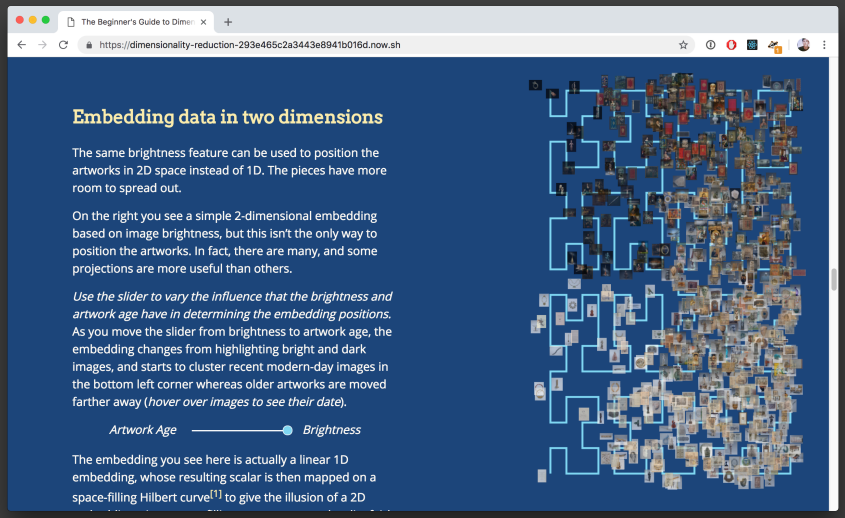
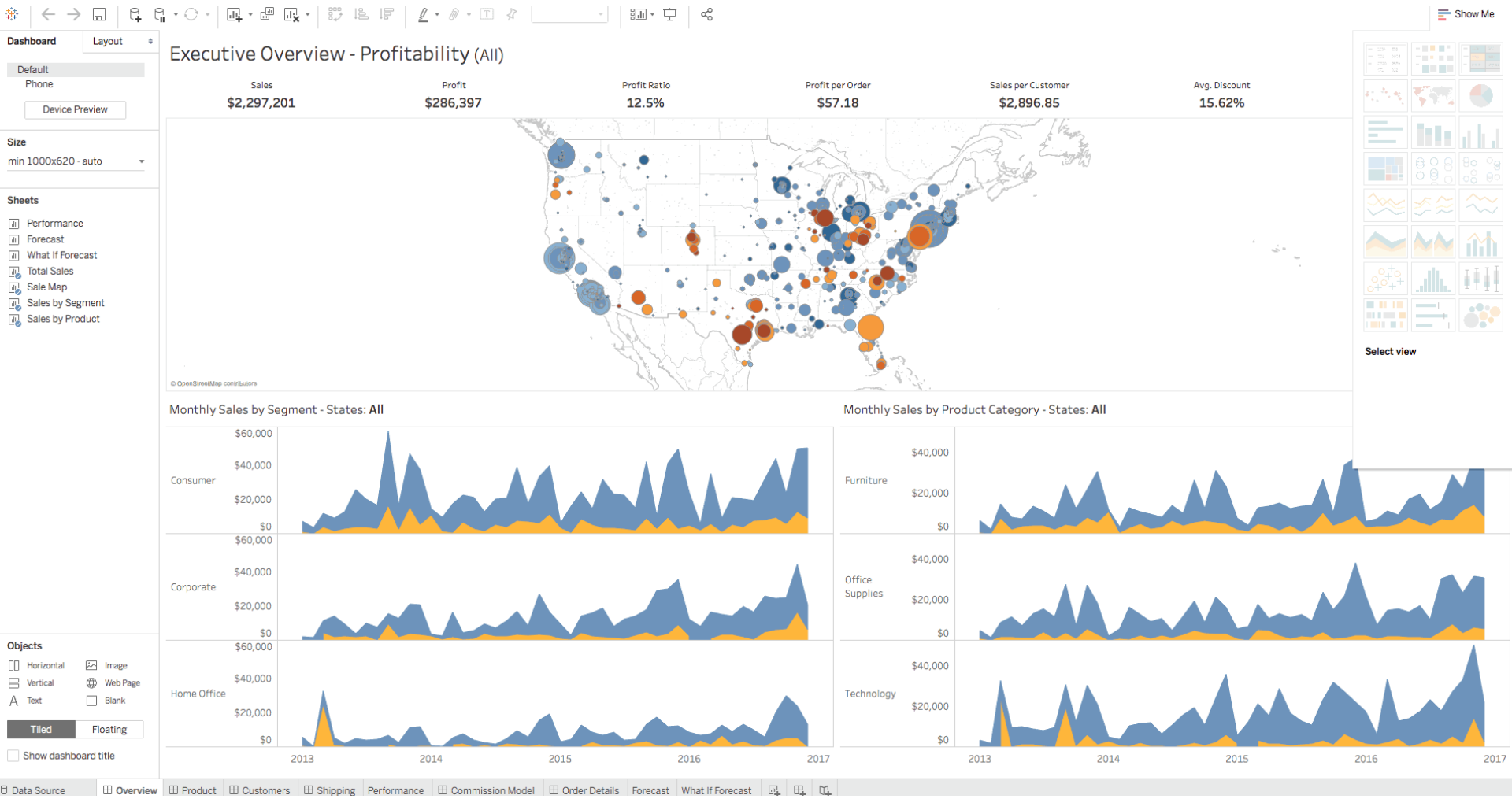


Chart Sequence Models

Multiple Charts in Data Analysis



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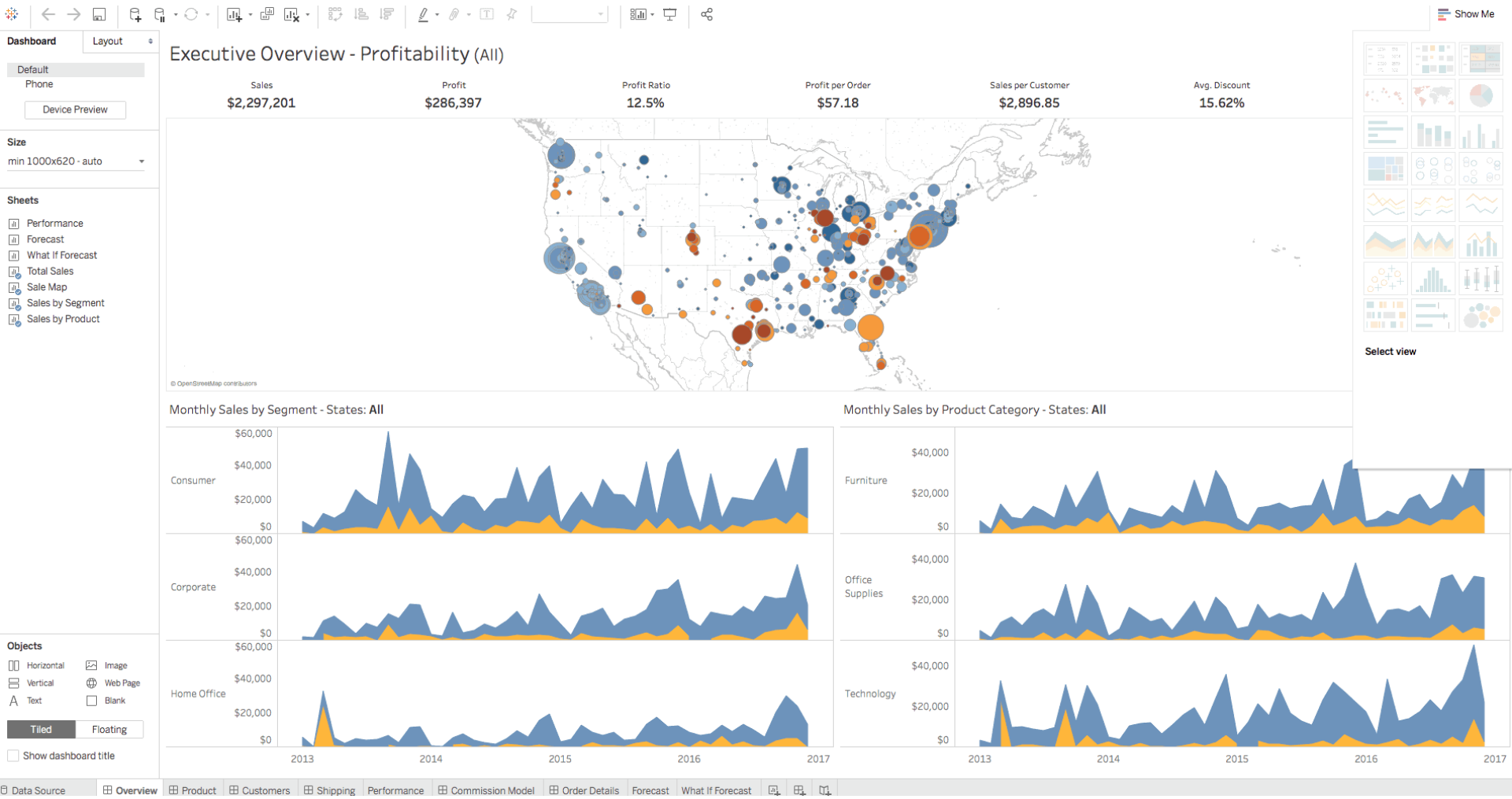

Multiple Charts in Story Telling

Copenhagen: Emissions, Treaties and Impacts

At the Copenhagen climate conference, discussions are likely to cover emissions levels, the legacy of the Kyoto Protocol and the risks of inaction on global warming. Explore each issue in the tabs below.

Global Emissions | **Lessons From Kyoto** | Possible Impact

1 2 3 4 5 6 7 8 9 10 11 NEXT ▸

Almost every country in the world signed and ratified the protocol. The treaty's aim was to provide a starting point for reducing global carbon dioxide emissions.

Countries that ratified Kyoto

By JAMES BRONZAN, AMANDA COX, XAQUÍN G.V. and KEVIN QUEALY | Send Feedback

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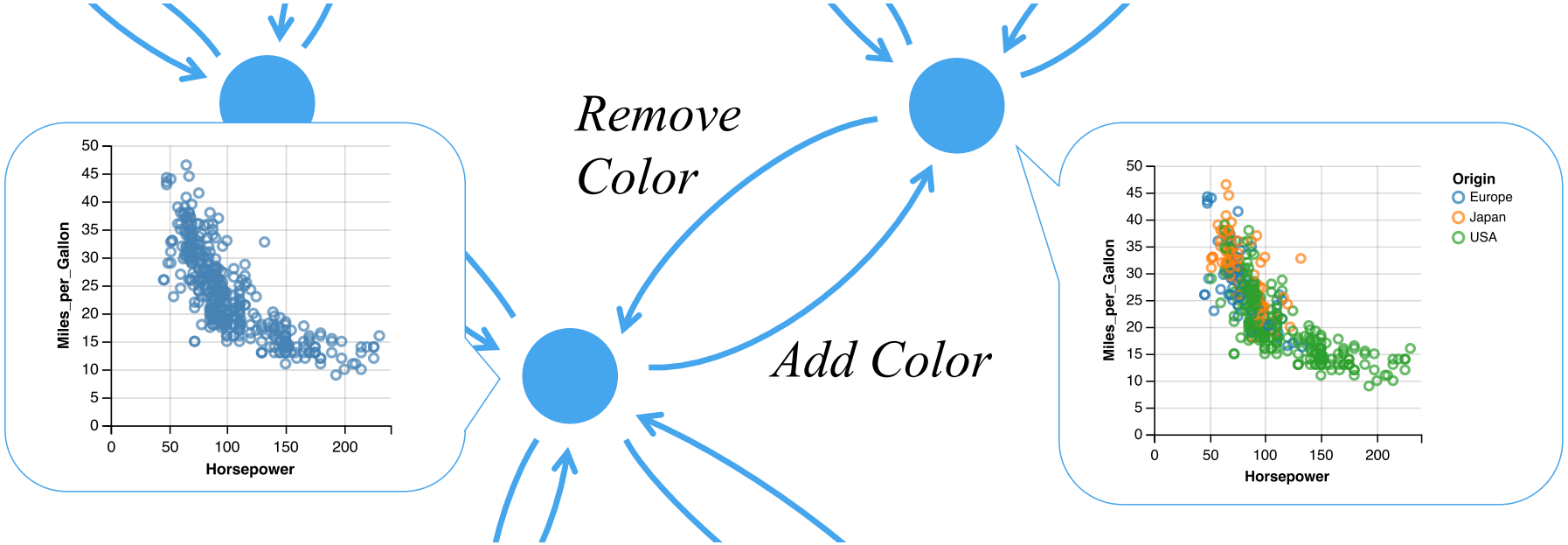
In many cases, data is conveyed via a sequence of charts.

How might we evaluate different orderings of visualizations?

GraphScape: A Directed Graph Model

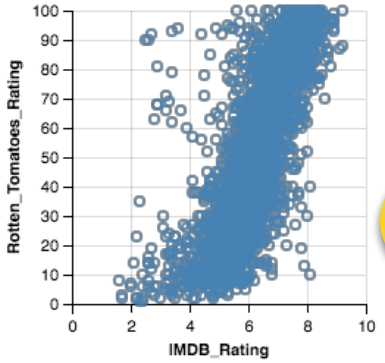


Nodes are **Vega-Lite specifications**. Edges represent **edit operations**, weighted by estimated **transition costs**.

[Kim, Wongsuphasawat, Hullman, Heer, CHI'17]

Design Alternatives

"Too many data points !"



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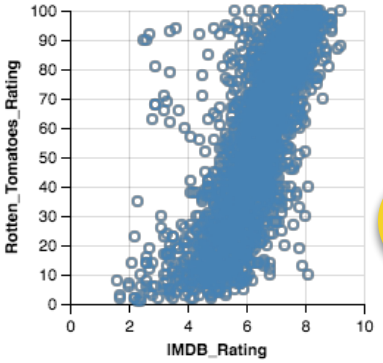

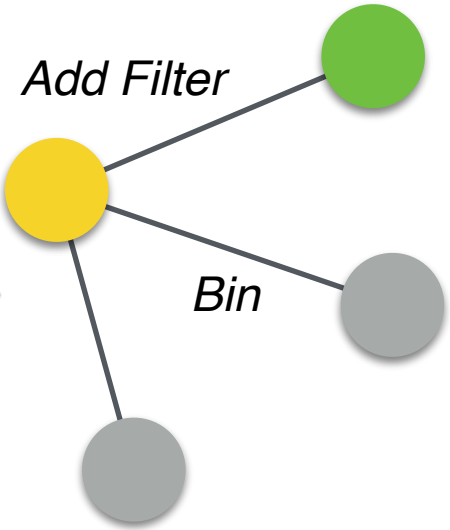

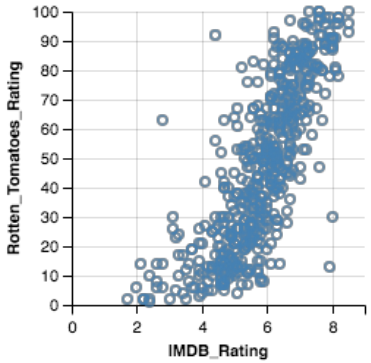

Random Sample

Design Alternatives

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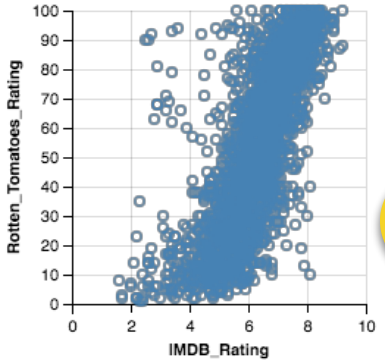

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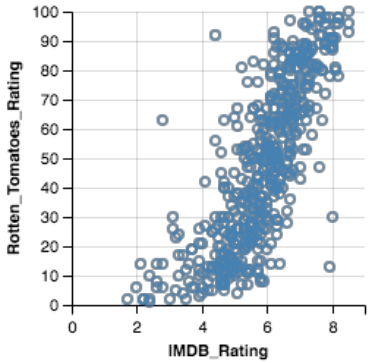
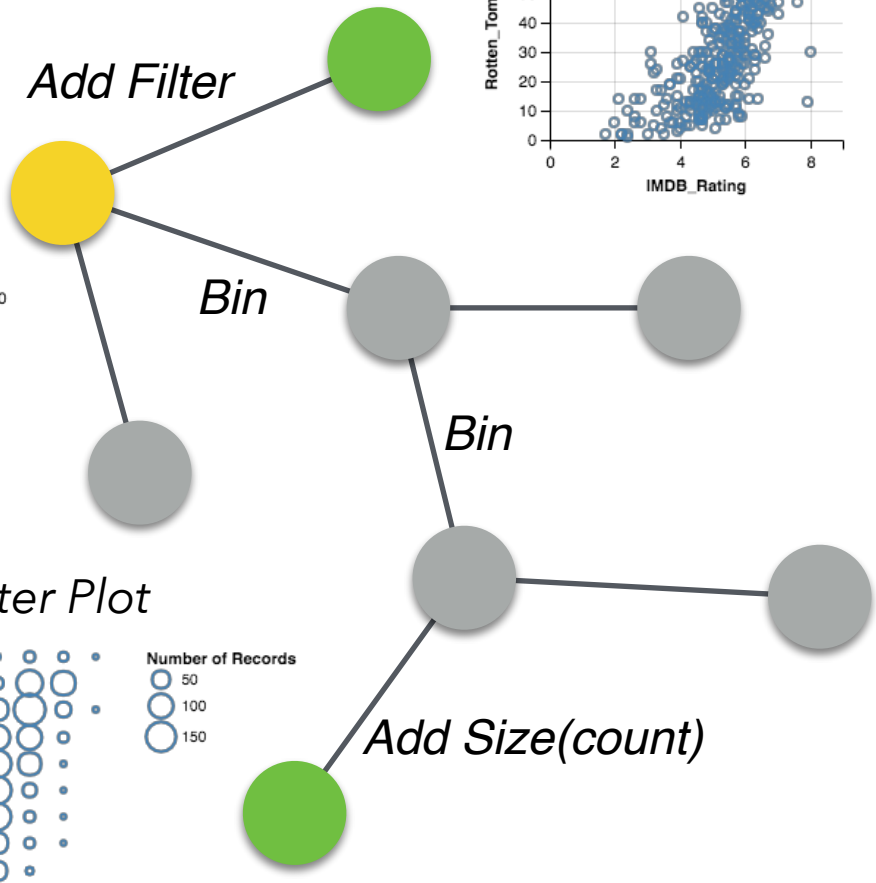
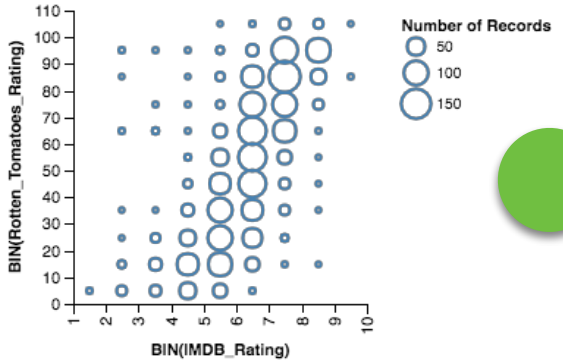




Binned Scatter Plot



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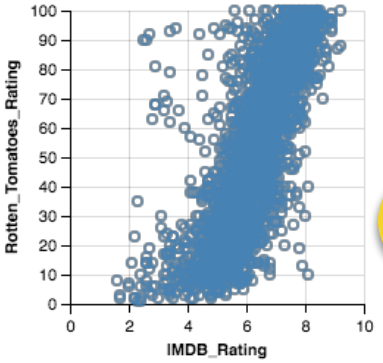
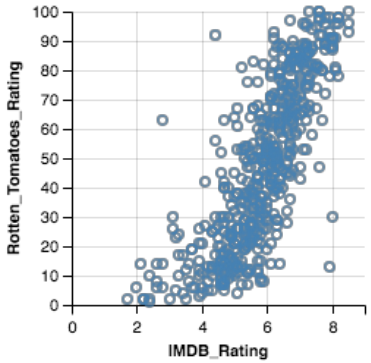


Random Sample

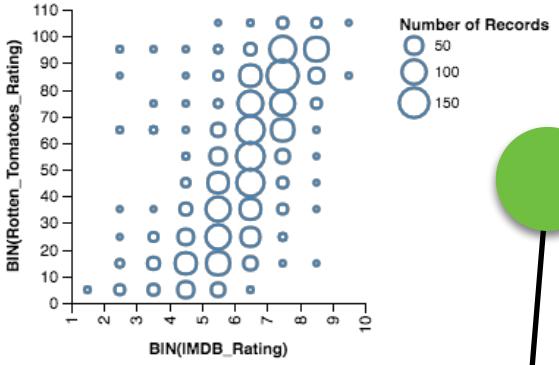


Add Filter

Bin

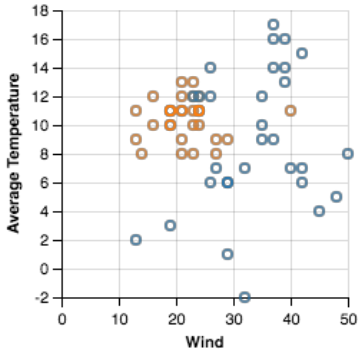
Bin

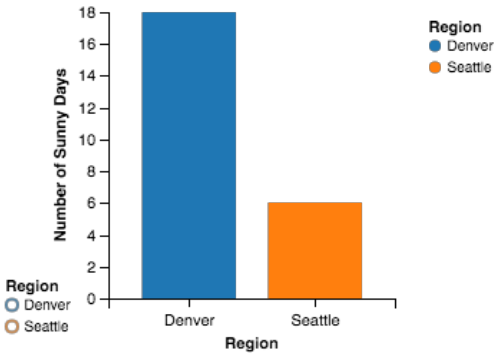
Binned Scatter Plot

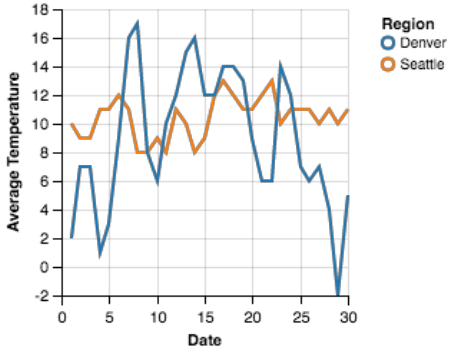


Add Size(count)

Sequence Recommendation







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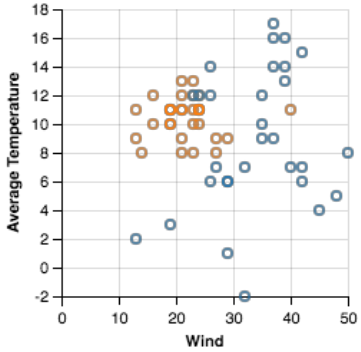

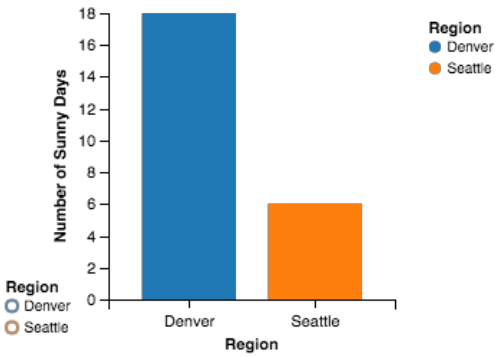

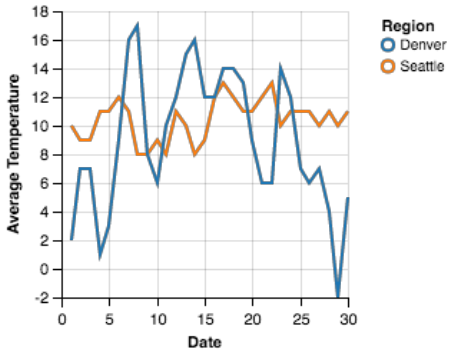

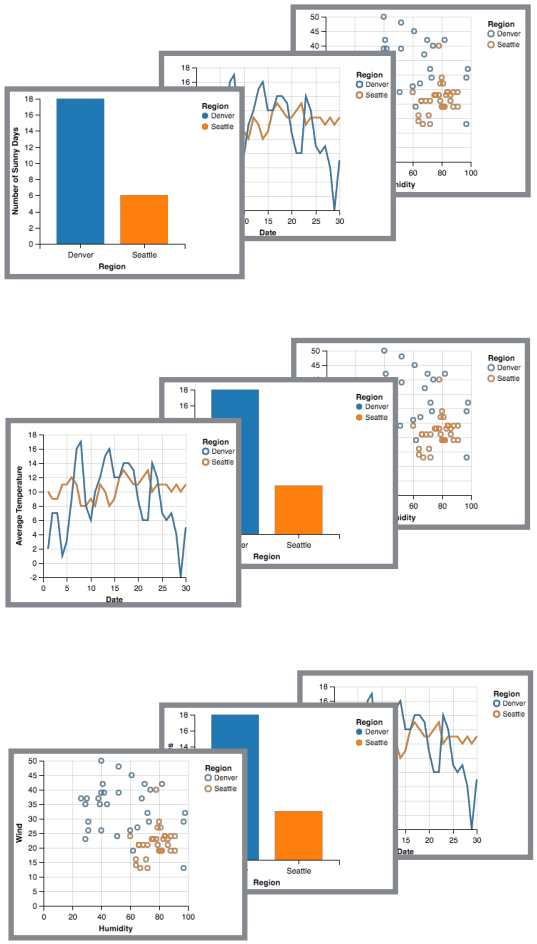

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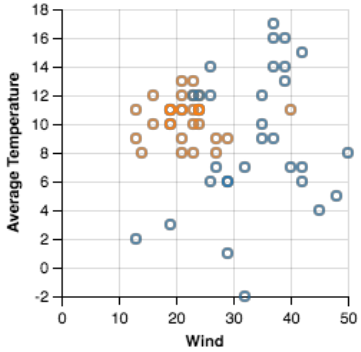

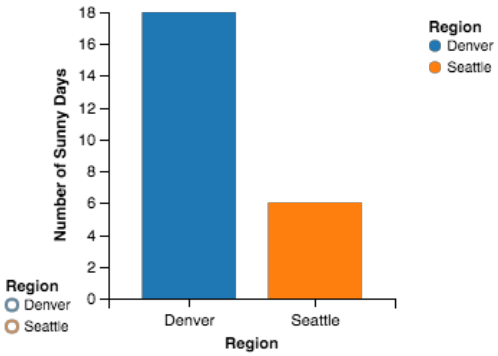

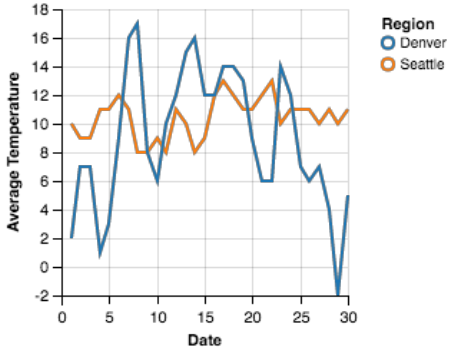

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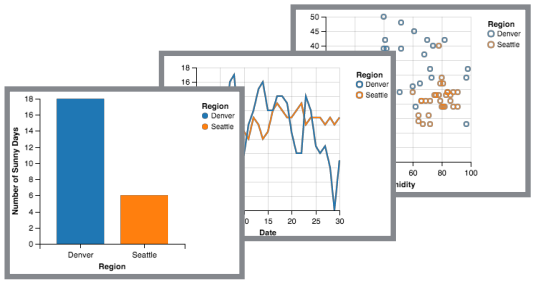

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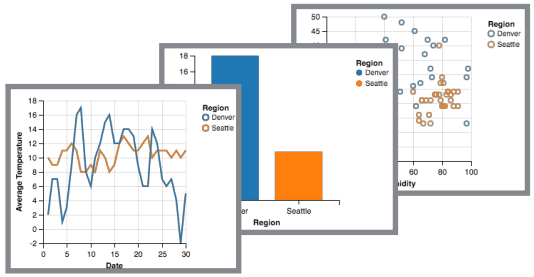

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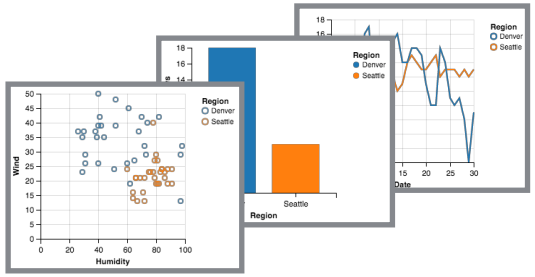

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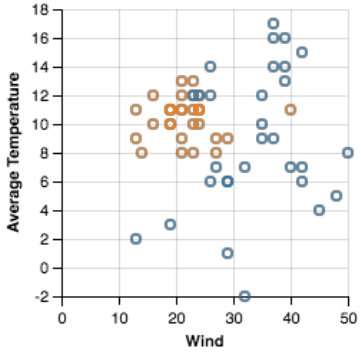
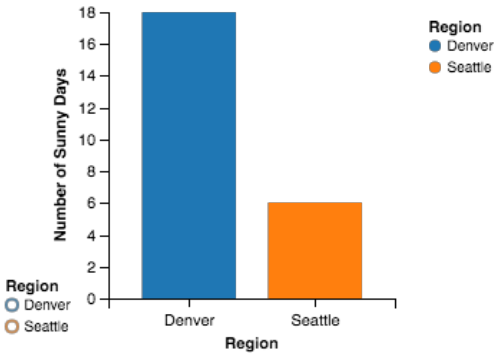
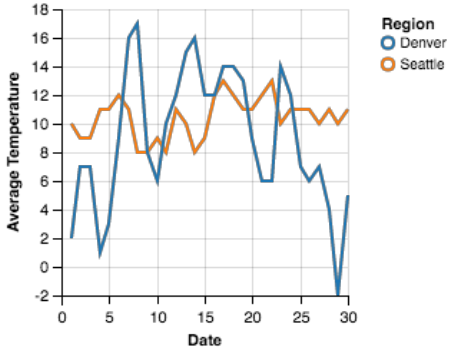
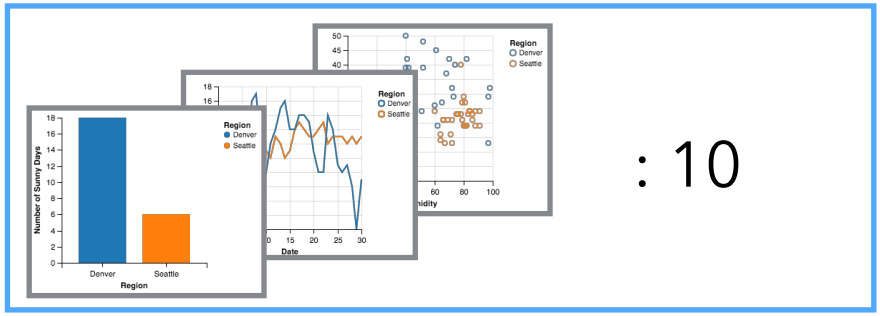
Sequence Recommendation







Sequence Cost



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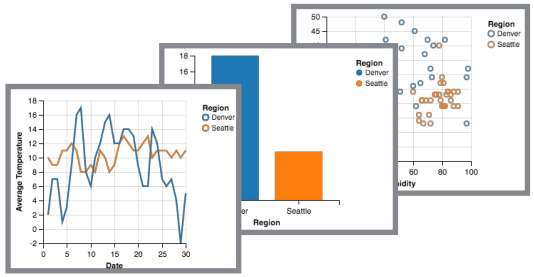

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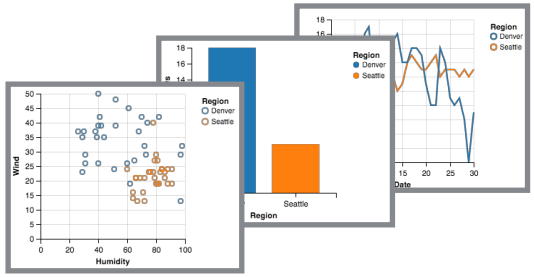

: 13

...

GraphScape

Previously we've discussed approaches for automatic design of a **single visualization**.

GraphScape supports automated design methods for **collections of visualizations**.

Plenty of future work to do here!